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# The

Paterson, N.J.

# Joint Committee on Sewage Disposal

of the

# CITY OF PATERSON

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## Report of the Joint Committee and of the Consulting Engineer on the Subject of Sewage Disposal

PATERSON, N. J.,
CHRONICLE PRINT
1906

# THE JOINT COMMITTEE ON SEWAGE DISPOSAL OF THE CITY OF PATERSON

COMMITTEE OF THE TAXPAYERS' ASSOCIATION

ROBERT M. CURTS, M. D., VERNON ROYLE,
HENRY J. HEWAT, WALTER B. JOHNSON, M. D.,
WILLIAM S. ACKERMAN, M. E.

COMMITTEE OF THE BOARD OF ALDERMEN

DAVID YOUNG, CHARLES W. MORGAN,
GEORGE A. FISCHER, JOHN BOYLAN,
JOHN J. DOWNEY.

CHAIRMAN:
ROBERT M. CURTS, M. D.

CONSULTING ENGINEER:
ALLEN HAZEN, MEM. AM. SOC. C. E. NEW YORK CITY.

SECRETARY AND TREASURER:
WILLIAM S. ACKERMAN, M. E.

5-8-44

# GENERAL NOTES ON THE PATERSON SEWAGE PROBLEM

There is probably no public question of any magnitude which receives so little attention from the general body of taxpayers as that of sewage disposal, and it is equally safe to say that, next to a good supply of pure water, there is none with which the community's interests are so inseparably associated.

Public health, natural beauty, and trade cannot be maintained apart from the treatment of sewage, which constitutes one of the most costly, complex, and difficult problems of the age.

Owing to ignorance, self-interest, and neglect, the rivers and streams have been converted into what are little better than open sewers; indeed, until stern necessity compelled serious attention to the magnitude of the evil and its ultimate trend, it was customary to look upon watercourses as the natural channels into which should be thrown all the refuse and filth which life and activity created.

The Passaic river, into which all of the sewers of Paterson empty, is the most important stream in the state of New Jersey.

It rises in the hills of Somerset County, flows northerly until it is turned eastwardly by Hook Mountain; it is joined by the Rockaway near Pine Brook, and receives the clear waters of Pompton river at Two Bridges; then, breaking through the barriers of Second and First mountain, it bears southwardly to Newark Bay and the ocean.

Its drainage basin covers 949.1 square miles, about 818 of which are in the northeastern portion of the State of New Jersey, while 132 are in the State of New York.

The river is generally rather turbid until it receives the pure mountain streams which collect in the Pompton; but from that point to Little Falls it is a bright and inviting river.

Throughout the extent of the Passaic Basin above Little Falls, there is but one municipality having a sewerage system—the town of Summit, in Union County, which discharges an effluent from filtering beds into the river. This evidence of contamination practically disappears before the river reaches Little Falls. There are some private drains at various points, but of no great significance. It is apparent, however, that the growth of population in the upper valley will soon compel other communities to adopt sewerage facilities, and as they cannot empty their sewers into the Passaic river on account of laws which were passed in 1897, prohibiting the pollution of the river above the Great Falls, they will of necessity be compelled to put in local disposal plants or send their sewage through the system which Paterson will adopt, either to be treated here or passed on with Paterson's sewage for treatment beyond, as the case may be.

The clear stream which enters the Borough of Little Falls receives the drainage of several residences and factories there, and with that the contamination of the Lower Passaic may be said to begin.

Until the diversion of the water in the upper watersheds and at Little Falls there was always a sufficient quantity of clean water flowing through the city to sufficiently dilute its sewage, but with the diminished flow owing to this diversion of the water to supply Newark, Jersey City, Montclair, and the Oranges, the quantity of water in the river between Great Falls and Dundee Dam is not enough to sufficiently dilute the increased daily discharge of sewage and manufacturing wastes of Paterson.

The condition of the river has become a nuisance to residents along the banks; it is an offense to sight and smell, and has caused depreciation in value of property; it is no longer desirable for pleasure purposes, boating, bathing, etc., and is objectionable for manufacturing purposes on account of the pollution.

This is the problem which confronts us today, and this Committee has spent many months in endeavoring to arrive at a practical solution of the same.

In considering the broad question of sewage disposal it should be clearly understood that no two sewages are alike, and consequently there is no universal remedy. Each separate sewage constitutes a problem of its own, to be diagnosed and treated with the full knowledge that in sewage, as in human beings, "one man's food is another man's poison." This all-important fact, strongly emphasized in large towns by varying industries, cannot be too thoroughly grasped, for the absence of such knowledge leads many well-meaning people to begin comparing methods of treatment, costs, and results obtained in one town with those secured in another, as though they were all dealing with the same standard commodity.

The varying character of sewage in regard both to quality and quanitity, calls for constant care and attention. In dry weather the quality, though ever varying, is strong, and the volume correspondingly small. In wet weather it is diluted in proportion to the rainfall; the quantity is correspondingly great, and the quality proportionately weak after the first flushing of the sewers. In the case of disposal plants, drastic changes, dependent upon nothing more formidable than a shower of rain, materially affect every process through which it passes, from the adding of the precipitant to the final discharge of the treated effluent into the stream, and demand conscientious watchfulness and intelligent oversight if efficiency and economy are to be obtained.

Public attention was first directed to the unsanitary condition of the Passaic river by the Board of Health of the City of Paterson in the early nineties.

From the annual report of the State Board of Health for the year 1895, the following notes have been taken:

"During the summer of 1894 the long drouth aided in bringing about conditions which rendered the dwellings along the borders of that portion of the Passaic river below the city of Paterson, and above Dundee dam, almost uninhabitable.

"The increase in the quantity of sewage discharged into the river at this point, keeping pace with the increase of population, and the drawing off of the impounded water for the use of the mills below the dam, together with the scanty rainfall, resulted in the pollution of the remaining fluid to a degree which caused it, under the influence of the summer sun, to emit offensive gas, thus fouling the atmosphere of the whole vicinity.

"Complaints and petitions flowed in upon the State Board of Health, asking that relief should be afforded against the continuance of this nuisance, but it found that no authority has been given to the State Board by the Legislature for action which would afford relief to the persons affected by the filthy river. Before any improvement can be secured in the condition of the river, a new method of sewage disposal must be provided by the towns and factories which are situated in the Passaic Valley.

"This undertaking should be preceded by an exhaustive inquiry, by skilled engineers, into the question of collection and final disposal of the sewage, and inasmuch as numerous municipalities will be affected by the construction of works for the relief of the river, and because it is not to be expected that any harmonious adjustment of the engineering and financial problems involved in the establishment of such works can be reached by agreement between the various local governments, it seems to be necessary that the state shall determine upon a course to be followed in the purification of the river."

With this purpose in view two bills were prepared and presented to the one hundred and nineteenth Legislature. Neither bill passed the Legislature.

In the annual report of the Board of Health of the City of Paterson, for the year 1895, the following statement appears in re the condition of the river:

"In our former reports allusions have been made to the condition of the Passaic river below the Falls, caused by the discharge into it of the sewage of this city. During the past year a good deal of work was done to remedy the matter. Notices were served on this city by the Boards of Health of Acquackanonk and Saddle River townships calling for the abatement of the nuisance within a given time. This city finding it impossible to comply, the matter was carried by the townships to the State Board of Health. Acting on the advice of the State Board a conference of the local Boards for the purpose of considering the matter was held. At the meeting the position of the city of Paterson was explained; that the discharge of sewage in the river was no doubt unfortunate; that the city of Paterson suffered from it more than anyone else; but that it was an utter impossibility for this city alone and unaided to find a remedy. The condition of affairs having been made plain to the representatives of the townships it was unanimously resolved to request the State Board of Health to have introduced into the State Legislature a bill calling for a State Commission to investigate and report a system of sewage disposal for the northern part of the State. This bill was introduced as requested but unfortunately did not pass. Undoubtedly the attempt will be made again at the next session, for the matter is a serious one and action on these lines seems the only solution."

## LEGISLATION.

The Legislature of New Jersey on February 26, 1896, enacted a law (being Chapter 7 of the Laws of 1896) entitled "An act for the consideration of a general system of sewage disposal for the Valley of the Passaic river and the prevention of the pollution thereof." This law provided for the appointment by the Governor of three citizens of New Jersey to consider the subject of the pollution of the Passaic river and for a general system of sewage disposal for the relief of the Passaic Valley. These persons were given power to employ engineering and other assistants and to report to the Legislature their conclusions, with maps, plans, methods of carrying out the work, an estimate of cost and a recommendation as to the method of apportioning the cost. The sum of ten thousand dollars was appropriated to defray expenses of this investigation.

A copy of this act in full is given on page 5, of the published report of the commission dated February 26, 1897, and forming item No. 2 of this synopsis. Governor Griggs appointed on April 21, 1896, as such Commission, Messrs. Elias J. Marsh, M. D., H. C. H. Herold, M. D., and William T. Hunt, who prepared and submitted to the Legislature on February 26, 1897, their report of the Passaic Valley Sewerage Commission which forms the following item:

### REPORT OF THE PASSAIC VALLEY SEWERAGE COMMISSION SUBMITTED FEBRUARY 26, 1897.

The Commission organized with the following officials and advisers: E. J. Marsh, M. D., treasurer; W. D. Scott, secretary; Joseph Coult, counsel; Alphonse Ftley, consulting engineer; C. E. A. Jacobsen, engineer; H. E. Abbot, A. W. Cuddeback, Robert F. Sayles, James A. Wylie, assistant engineers; Herbert B. Baldwin, chemist, and Richard N. Connolly, M. D., bacteriologist.

The report of the Commission contains the individual reports of the engineers, the secretary, the chemist and the bacteriologist together with the general conclusions and recommendations of the commission including the draft of "An act providing for the purification of the rivers and streams of water within this State and to prevent the pollution of the same."

## ACT TO PREVENT THE POLLUTION OF THE UPPER PASSAIC RIVER.

The Legislature of New Jersey enacted on March 24, 1897, (forming Chapter 35 of the Laws of 1897) an act to prevent the wilful pollution of the Passaic river and the tributaries thereof above the Great Falls of the Passaic river at Paterson. This law was evidently intended to protect the purity of the potable water supply of the East Jersey Water Company and has no very important bearing on the efforts to reduce the pollution of the lower Passaic Valley.

## LEGISLATIVE COMMITTEE.

Owing to a strong opposition to the terms of the draft of the bill recommended by the Commission of 1896 the bill was not brought up for passage but in place thereof an act was passed authorizing a committee of members of the Legislature to study the subject and to report at the next session what should be done in the matter. The committee consisted of Senators Robert Williams, and W. M. Johnson and Assemblyman T. C. Wildman. During 1897 this committee held public meetings and listened to arguments for and against the proposed legislation. In the spring of 1898 the committee reported as a result of its labors that the whole matter ought to be studied again by a new commission and presented a bill providing for a commission of eight persons, three of whom were to be members of the original commission of 1896. The bill was passed and Governor Voorhees on Aug. 3, 1898, appointed the following commissioners: Mr. William T. Hunt, Dr. H. C. H. Herold, Dr. E. J. Marsh, Hon. John Hinchliffe, Dr. James

A. Exton, Hon. Charles W. Fuller, Hon. Charles F. Harrington, and Mr. William Kent.

## STATE SEWERAGE COMMISSION.

The Legislature of 1899 on March 24th enacted a law (forming Chapter 210 of the laws of 1899) entitled "An act to prevent the pollution of the waters in this state by the establishment of a State Sewerage Commission, authorizing the creation of sewerage districts and district sewerage boards and prescribing, defining and regulating the powers and duties of such commission and such boards."

This act provided for the appointment by the Governor of five citizens of the state to compose the "State Sewerage Commission," the duties of which commission are to investigate the various methods of sewage disposal and to investigate all complaints of pollution of the waters of the State and to advise as to the best methods of sewage disposal in order to prevent such pollution and to pass on, approve or disapprove of all plans for sewage disposal into the waters of the State before such systems can lawfully be built and the sum of five thousand dollars was appropriated to enable the commission to carry out the provisions of the act. The act also provided for the formation of "sewerage districts" and the appointments of "sewerage boards" each board to comprise two members of each municipality within the district to be appointed by the governing body of each such municipality and one member to be appointed by the State Sewerage Commission. These district boards were to be considered as corporate bodies and were given powers to investigate, design, construct, maintain and operate systems of sewerage and drainage or systems of sewage disposal works or both and were given the power to condemn and appropriate lands and to issue bonds.

This act was re-enacted in a somewhat amended form by the Legislature of 1900 (forming chapter 72 of the Laws of 1900).

It is to be noted that the functions of this State Sewerage Commission are general and are not confined to the Passaic Valley.

The first commissioners to be appointed under this act were as follows: Charles F. Harrington, Hon. John Hinchliffe, Wm. T. Hunt, Charles W. Fuller, David L. Wallace.

This State Sewerage Commission has submitted several annual reports referred to as follows:

ANNUAL REPORT OF STATE SEWERAGE COMMISSION FOR 1899.

This report forms document No. 48 of volume V, of Legislative Documents for 1899. As no appropriation was made for the expenses of the commission no engineering investigations were made during the year, but the commission gathered a large amount of information concerning the sewerage of the cities and villages of the State on circular blanks issued by the commission. The commission recommended to the Legislature that additional powers be given the commission by which they might compel the abatement of existing pollution and also recommended that authority be given to two or more municipalities to co-operate in providing sewerage and disposal. The commission also submitted a draft of a bill amending the existing law (chapter 210 of the Laws of 1889) so as to provide the above and several other proposed features.

ANNUAL REPORT OF THE STATE SEWERAGE COMMISSION FOR 1900.

This report comprises document No. 49 of Volume V of Legislative Documents for 1900. The Legislature of 1900 amended the original law establishing the State Sewerage Commission and reenacted it as chapter 72 of the Laws of 1900. On June 4, 1900, the State Sewerage Commission adopted a resolution as follows:

*Resolved,* That under authority of chapter 72 of 1900 that prior to June 1, 1904, the municipalities of Paterson, Passaic, Rutherford, Newark, Orange, East Orange, Montclair, Bloomfield, Glen Ridge, Kearney, Harrison and East Newark now polluting the waters of the Passaic river with sewage, must cease to pollute the waters of the said river and make such disposal of the sewage and other polluting matter of such municipalities as shall be approved by this Commission.

During the year the Commission received and considered a number of complaints and petitions and passed on plans for sewerage and sewage disposal for a number of municipalities in the state. The subject of sewage disposal in Great Britain and France was investigated by Chairman William T. Hunt who inspected and reported on the system in use in London, Paris, Leeds, Manchester, Glasgow and Edinburgh. No extended engineering investigations were made by the commission during this year owing still to lack of funds. Black Bound Rept., 1901.

### ANNUAL REPORT OF STATE SEWERAGE COMMISSION FOR 1901.

This report forms document No. 49 of Volume V of Legislative Documents of 1901. Governor Voorhees transferred to the commission eight thousand dollars from his emergency fund, which enabled the commission to undertake some engineering work. This work was all confined to the Passaic Valley problem as being the most important single sewerage problem in the State and consisted in the making of surveys and plans for the system of intercepting sewers extending from Paterson along Passaic river to Newark bay with plans for sewage disposal. A part of this work was undertaken by Messrs. Colin R. Wise, Robert M. Watson and William Ferguson, engineers, and the remainder by Mr. James Owen, C. E., and reports were submitted for these two divisions of the engineering work. These reports with the maps and plans accompanying them were then submitted to a board of consulting engineers comprising Messrs. Rudolph Hering, J. J. R. Croes and William M. Brown, who examined and reported not only on the plans as already submitted, but also on alternate features. The conclusions of the board of consulting engineers were that the most efficient and economical system of disposal for the Passaic Valley from Paterson to Newark bay was a system of intercepting sewers without sewage treatment by which the entire sewage of the municipalities along the valley should be brought to New York bay. The commission also submitted a number of technical questions regarding the sewage disposal to Mr. H. W. Clark, chemist of the Massachusetts State Board of Health and the report contains the answers of Mr. Clark on these questions. In addition to the Passaic Valley investigations the commission also considered the cases of a number of municipalities and streams throughout the state and ordered a number of municipalities to cease the pollution of certain streams at certain stipulated dates. The commission also approved during the year plans for sewerage and disposal for a number of municipalities in the state.

## ANNUAL REPORT OF THE STATE SEWERAGE COMMISSION FOR 1902.

This report forms document No. 33 of Volume III, of Legislative Documents for 1902, submitted to the Legislature of 1903, the Legislature of 1902 having passed an act (Chapter 48 of the Laws of 1902) establishing a separate sewer district for the Passaic Valley and creating a commission therefor. The state commission devoted its energies to other portions of the state, placing the services of its members and the official records and material at the disposal of the Passaic Valley Sewerage Commission.

The Legislature of 1902 passed an act (Chapter 49 of the Laws of 1902) which was approved March 27, 1902, providing that the Legislature might create and incorporate sewerage and drainage districts, and providing for the appointment, by the Governor, of boards of sewerage commissioners of five residents of each such districts.

## PASSAIC VALLEY DISTRICT SEWERAGE COMMISSION.

The Legislature of 1902 passed an act (Chapter 48 of the Laws of 1902) which was approved March 27, 1902, entitled "An act to create a sewerage district to be called Passaic Valley Sewerage District."

The Governor appointed under the foregoing acts the following gentlemen, to comprise the Passaic Valley Sewerage Commission: Messrs. J. A. Lebkuecher, John Hinchliffe, Francis Child, Peter Houck and William McKenzie.

This Commission organized on April 22, 1902, by the selection of Mr. J. A. Lebkuecher as chairman, and John S. Gibson as clerk. On August 18th the Commission appointed Mr. Rudolph Hering, of New York, as its chief engineer. This Commission submitted its first annual report to the Legislature on January 23, 1903.

## ANNUAL REPORT OF THE PASSAIC VALLEY DISTRICT SEWERAGE COMMISSION FOR 1902.

The report was submitted on January 23, 1903, and contains, beside the general report of the commission, the report of its chief engineer, Mr. Rudolph Hering, and also the draft of the proposed bill which should more thoroughly provide for the carrying out of the sewerage improvements recommended by the commission.

The report of Chief Engineer Hering describes his surveys, examinations and conclusions on the study of two alternate general plans of improvement; namely, first a system of intercepting sewers, extending from Paterson to Newark bay, by which the sewage of this portion of the valley should be brought to a discharge into the waters of upper New York bay without purification; and second, a system of intercepting sewers, but in place of crude disposal into New York bay the use of one or more purification plants, in which the sewage should be treated, and the purified effluent discharged into the Passaic river or Newark bay. Mr. Hering's conclusions favor the adoption of the former method. This system, which is the one now authorized for construction, comprises a main intercepting sewer, extending from a point near the Great Falls of the Passaic, in the city of Paterson, along the right and westerly bank of the Passaic river to a point in the city of Newark, where it leaves the river and passes southeasterly through the city across the salt meadows to a point on the shore of Newark bay opposite West Bergen Point, where a main pumping station is to be located. Down to the site of the pumping station this is to be a gravity sewer, but two auxiliary pumping stations are proposed, one at Wallington and one at Lyndhurst, where sewage from low level sewers on the left bank of the Passaic river is to be pumped across the river and into the main intercepting sewer. The pumping station on Newark bay is to force the sewage through two 6 feet diameter steel force mains under Newark bay and up into a gravity sewer which is on the eastern shore of Newark bay in Jersey City at the Morris and Essex canal. This gravity sewer, 13 feet in diameter, leads southeasterly along the canal to a point jutting out into upper New York bay near Panrapo where the sewer changes to the eight-feet steel pipe laid under New York bay up to a point about three-quarters of a mile northeast of Robbin's Reef light in a depth of about 40 feet of water below the mean low tide.

This report also contains the draft of the bill which the commission recommended to the Legislature as being necessary to carry out the improvement proposed. This bill in a somewhat modified form was enacted on April 22, 1903.

### THE ACT OF APRIL 22, 1903.

This act modified somewhat from the form recommended by the commission providing for the full powers of the commission and for the procedure to be followed in executing the sewerage improvement under consideration. One of the provisions of this act was that before any work should be undertaken or obligations incurred the Passaic Valley District Sewerage Commission should investigate whether the proposed discharge of sewage into New York bay is likely to pollute the waters of said bay to such an extent or in such a degree as to cause a nuisance to persons or property within the State of New York, and required that the result of such investigation should be presented to the Governor with the opinion of the Commission thereon and the reasons for their opinion; thereupon that the same should be considered by the Governor and the Attorney-General and that no work or further proceedings be taken unless the Attorney-General should in writing advise that no cause of action either for damages or an injunction would arise in favor of the State of New York or any of its inhabitants by reason of such discharge of sewage into the waters of New York bay.

### SPECIAL REPORT OF THE PASSAIC VALLEY DISTRICT SEWERAGE COMMISSION SUBMITTED JUNE 8, 1903.

Pursuant to the requirement of the law above quoted the Passaic Valley District Sewerage Commission investigated the subject and reported as their opinion that the discharge of the sewage from the proposed Passaic Valley sewer would not pollute the waters of New York bay to such an extent or to such a degree as to cause a nuisance to persons or property within the State of New York. The Commission submitted as a warrant for its conclusions copies of the written opinions of General Henry M. Robert, George S. Greene, Jr., E. W. Harrison, O. H. Tittmann, William Barclay Parsons and Allan N. Spooner.

## GOVERNOR MURPHY'S AUTHORIZATION TO PROCEED.

Governor Murphy having examined the special report submitted by the Passaic Valley District Sewerage Commission referred the same to Attorney-General McCarter for his legal opinion. The Attorney-General having examined the report and having further investigated the case advised the Governor that he found no legal objection to the building of the trunk sewer proposed and that in his opinion there would be no legal objection from the authorities of New York. Thereupon Governor Murphy authorized the sewer commissioners to proceed to the construction of the improvements contemplated.

## CONSTITUTIONALITY OF ACT OF APRIL 22, 1903, MAINTAINED BY NEW JERSEY SUPREME COURT.

The acts of 1902-03 were attached by writ of certiorari by the city of Paterson and a citizen of the State, the proceedings bringing up for review the validity of the resolution by the Passaic Valley District Sewerage Commission providing for an issue of $1,000,000 worth of bonds for preliminary work connected with the trunk sewer. The case was argued before three justices, two of whom sustained the constitutionality of the act, handing down their opinion July 23, 1904.

## ACT OF APRIL 22, 1903, DECLARED UNCONSTITUTIONAL BY THE NEW JERSEY COURT OF ERRORS AND APPEALS.

An appeal was taken from the decision of the Supreme Court as rendered, and on March 6, 1905, the Court of Errors and Appeals, by a vote of ten to one, reversed the decision of the Supreme Court previously referred to, and declared the act of 1903 unconstitutional, as it is an attempt to delegate an essential element of the power of taxation; because if the taxing power could be deemed to be granted to the commission as a representative of the sewer district, the latter is not a political district of the State, and because if the Passaic Valley Sewerage District were a political district of the State it could not be invested with the power to tax persons and property beyond its own limit.

The Committee has been assisted in the preparation of this report by extracts from the following publications:

Notes on the Bradford Sewage Problem by Councillor E. J. Smith.

Report of the New York Bay Pollution Commission.

Reports of the State Sewerage Commission.

Report of the State Board of Health for 1895.

Report of the Paterson Board of Health for 1895.

Reports of Passaic Valley Sewerage Commission.

Commissioner's Report on the Passaic River Pollution, 1898.

Legislative Committee's Report to Legislature, 1898.

At a meeting of the Taxpayers' Association held in Masonic Hall in August, 1905, the subject of sewage disposal of the city and the purification of the Passaic river was discussed by the citizens of the city.

After a thorough discussion the following resolution was adopted:

"That the Chair appoint a committee of five to investigate and report some method of disposing of the sewage of Paterson, other than a trunk sewer."

Pursuant to the above resolution, Mr. Charles N. Sterrett, chairman, appointed the following gentlemen to serve on the Committee:

R. M. Curts, M. D.,
Vernon Royle,
Walter B. Johnson, M. D.,
Henry J. Hewatt,
William S. Ackerman, M. E.,

and as advising members,

Frederick Beggs,
H. J. Harder, City Engineer.

The gentlemen above named having accepted Chairman Sterrett's invitation to serve, met at the Hamilton Club on September 13th, 1903, and organized with R. M. Curts, M. D., as chairman, and H. J. Harder, as secretary and treasurer.

With regard to the scope of the Committee's work it was found that a difference of opinion existed; some members claiming that the Committee should follow absolutely the instructions in the original resolution, i. e., that the Committee should investigate and report upon some method of disposal of sewage other than a trunk sewer; while other members of the Committee thought that as the City of Paterson had never had figures on a trunk sewer by an expert in its own employ, and as the figures given by the Newark engineers might be too low, these members believed that the Committee should go into the study of all methods of sewage disposal including that of a trunk sewer, in order to report what in their opinion was the best method for the City of Paterson to adopt.

As the result of this discussion Dr. W. B. Johnson offered the following resolution:

> "Resolved, that before finally undertaking the work, your committee would request information upon the following:
>
> First. The scope of the Committee's work;
>
> Second. The amount of expense the Committee may incur in the prosecution of the work;
>
> Third. The question of employment of consulting engineers or other experts."

In answer to these questions your Committee subsequently received instructions from the Executive Committee of the Taxpayers' Association, to extend the original scope of the work of the Committee to the full investigation of all methods for the disposal of sewage as affecting the interests of the City of Paterson. It was further stated that the Taxpayers' Association would be responsible for the ordinary expenses of the Committee in the prosecution of its work. The question of the employment of a consulting engineer was left for future consideration.

As the work of the Taxpayers' committee progressed it was found advisable to interest members of the Board of Aldermen in this project, with the result that the Executive Committee of the Taxpayers' Association requested Acting Mayor Young to appoint a committee from the Board of Aldermen to confer with the special committee of the Taxpayers' Association on the question of sewage disposal for the city of Paterson. Pursuant to this request Acting Mayor Young appointed the following members of the Board of Aldermen to serve as a committee:

GEORGE A. FISCHER,
CHARLES W. MORGAN,
DAVID YOUNG,
JOHN BOYLAN,
JOHN J. DOWNEY.

These members of the aldermanic committee and the members of the special committee of the Taxpayers' Association met together and effected a re-organization to be known as the Joint Committee on Sewage Disposal for the City of Paterson, with the following officers:

R. M. CURTS, M. D., Chairman.
WILLIAM S. ACKERMAN, M. E., Secretary and Treasurer.

At the subsequent meetings of the Committee up to November 15, discussions were held upon reports of the Taxpayers' Committee, giving in detail the results of their observations of sewage plants throughout New England, and of the advisability of employing expert engineers to assist the Joint Committee in their future work. On November 15, Dr. Calhoun, of Rutherford, addressed the Committee on his scheme of purifying the Passaic river by means of storing water for flushing purposes on the Great Meadows above Pine Brook. A number of the members of the Board of Aldermen were present at this meeting, and, after Dr. Calhoun's address, the different members of the Board of Aldermen were asked for their opinion as to the advisibility of employing expert engineering advice. As a result of this discussion it was moved by Alderman Fischer, seconded by Alderman Morgan, that the Board of Aldermen be requested to place ten thousand dollars at the disposal of the Joint Committee for expenses in regard to solving the question of sewage disposal for the city of Paterson, and that the City Counsel be requested to draw up a proper resolution for presentation to the Board.

On November 27, 1905, the following resolution was adopted by the Board of Aldermen:

> "Resolved, that the Board of Aldermen appropriate a sum of money not to exceed ten thousand dollars ($10,000) for the purpose of employing an expert engineer to investigate the sewage disposal of the City of Paterson, and for such other expenses as the special committee of this Board appointed for that purpose may incur; said money to be under the control and direction of the Finance Committee of this Board, to be paid out upon sworn bills approved by said Committee and the said special committee"

Before proceeding to the engagement of an engineer your Committee felt that the citizens of the city, the press and those interested should have an opportunity to express their views on the subject. At a public hearing given in the City Hall on December 5th, 1905, a number of citizens and representatives of the press were unanimous in the opinion that the Committee were proceeding on the proper lines, and were thoroughly competent to carry through any investigation necessary to accomplish the results desired; and endorsed the recommendations of the Committee for the expenditure of ten thousand dollars for expert advice.

After a thorough investigation of the qualifications of the most prominent engineers in the country, the appointment of Mr. Allen Hazen, of New York, was recommended by the Joint Committee as consulting engineer, on December 27th, 1905; and on January 1st, 1906, the Board of Aldermen formally engaged Mr. Allen Hazen as consulting engineer to the Joint Committee on Sewage Disposal.

It had been previously arranged among the members of the Committee, that meetings of the body should be held every other week, to consider the reports, on the progress made by Mr. Hazen in his work; to consider the reports of the members of Committee, who had visited other cities for the purpose of studying the sewage problem; and to conduct the ordinary routine work of the Committee.

For the purpose of practical investigation members of the Committee visited a large number of sewage disposal plants, in the New England States, and neighboring towns, and also in England, Ireland and Scotland, formulating reports on the work thus prosecuted, and presenting the same for the consideration of the Committee.

The first report presented to the Committee was one on the sewage disposal plant at Jamacia, Long Island.

The Committee early in September visited the sewage disposal plant at Jamacia, Long Island, situated close to the bay, and here they found chemical precipitation system in use, the plant having been designed by Mr. Powers, who kindly accompanied the Committee and explained the workings. The amount of sewage treated was 2,500,000 gallons per day.

It was determined that inasmuch as the effluent from these works attained a purification amounting to about 50 per cent and was discharged into a large body of water, the result obtained did not appear to be applicable to the conditions of the City of Paterson, because the emptying of a putrescible effluent of this character into the Passaic river would still leave it in an impure and unsatisfactory condition.

The next report received by the Committee was one prepared after visiting the sewage disposal plants of the New England States. It was found from observation that the experimental stations in Boston, and Lawrence, where the experiments had been carried along the lines of septic tanks, sprinkling filters, intermittent sand filtration, and contact beds, that the most approved system seemed to be the septic tanks and sprinkling filters, as least land was required when these were adopted. The experiments were carried on primarily with a view of ascertaining correct designs for local purification works, but from the data obtained some of the more modern sewage disposal plants in this country have been designed. The advantage of experimenting with sewage, before ultimately adopting any particular form of filter bed, has been demonstrated in the case of Columbus, Ohio, where $46,000 was set aside for the purpose of establishing an experimental plant, to determine the best method of dealing with the sewage peculiar to that city.

One of the great troubles in determining the methods of disposal is the varying quality of sewage found in different communities.

The members of the Committee next visited the Metropolitan System of trunk sewers at Moon Island, Boston, where 163,000,000 gallons per day is emptied into the bay. This is put out on ebb tide, and there did not seem to be any perceptible impurification at the time we were there except from the screw of the tug which churned up the sludge at the bottom of the bay near the outlet at low tide, showing that a considerable proportion of the solid matter was precipitated at that point.

At Deer Island, a station on the same system, the sewage is discharged continuously, and at the outlet the presence of sewage in the water of the bay is perfectly apparent. There was no strong odor perceptible.

At Framingham and Natick intermittent filtration on land, naturally adapted for the purpose, is the system employed, and this with considerable success; the effluent from these filter beds being practically perfect as far as purity is concerned and there was no perceptible odor from the filters, but the plants are small, and if adapted in Paterson would require large areas of land which would have to be specially prepared. Mr. Frost, the superintendent, said that he had no trouble during winter weather, and kindly explained the workings of the system. It is interesting to note that the purely farming operations on the Framingham plant yielded a net profit of ten dollars per acre.

The treatment of sewage in Worcester began first with the employment of the method of chemical precipitation. This was found to be inadequate to obtain the necessary purity of effluent required. The city subsequently experimented with septic tanks, and contact beds and sand filters, and recently in order to secure a proper effluent they combined the chemical precipitation with intermittent sand filtration; and are at the present time increasing the plant by the formation of many acres of intermittent sand filtration beds, with the hope that they will be able to produce a satisfactory effluent.

The cost of preparing an acre of filter bed here was originally $5,000, but has been somewhat reduced. The trouble with this system is the small amount of sewage which can be purified per acre as compared with the other and later systems and therefore it would be impractical were it applied to Paterson on account of the large quantity of land required. The average daily flow of sewage is only 23,000,000 gallons.

In the City of Providence the method employed is chemical precipitation without further treatment. The effluent is discharged into the bay at a narrow point, the water being forty feet in depth. There had been no particular complaints about the odor, although the appearance of the effluent was no improvement on the raw sewage. The precipitated sludge was pressed and spread on the waste lands about the works. There was no effort made to filter the effluent, and there seemed to be an opinion that probably it was the best they could do under the present conditions; although not entirely satisfactory as the actual purification by the chemical precipitation was only about 50 per cent.

From the observations made on this tour of inspection in New England the discussion of the following points should be considered:

1. The financing of the project;
2. The proximity to a place for sludge disposal;
3. The degree of purity of the effluent required;
4. The land necessary for any system;

It might be stated that good effluents can be obtained by

1. Slow filtration through sand or intermittent filtration;
2. Septic tank treatment and sprinkling filters;
3. Chemical precipitation with subsequent treatment.

Impure effluents but satisfactory for certain conditions, can be obtained by

1. Chemical precipitation without further treatment;
2. Rapid filtration through coarse material.

And that to determine a system for local disposal a type of sewage ought to be experimented with; and a thoroughly unbiased and as competent an engineer as can be found in the country should be employed to render a decision as to methods of treatment, and the costs of the same.

This Committee desires to acknowledge the courtesies extended to them on this visit to New England of Mr. H. W. Clarke, chemist of the State Board of Health of Massachusetts, in charge of the Lawrence Experimental station; Mr. Johnson and Mr. Pratt, the engineers in charge of the experimental station, at Columbus, Ohio; Mr. Green, Mr. Fuller, Mr. Phelps and others of Boston; Prof. Kinnicutt, director of the Worcester Polytechnic Institute; Mr. Eddy, superintendent of sewers and in charge of the sewage disposal works at Worcester; Mr. Frost, superintendent of the Framingham works; Dr. Chapin, superintendent of the Board of Health of Providence; Mr. Clapp, city engineer of Providence.

About this time a report was received from Mr. James Barr, consulting engineer of Glasgow, Sootland, to whom the case of Paterson had been represented. This report stated that an independent plant figured on the Glasgow basis would in all probability, assuming a slightly larger charge for work in America, cost the community $10 to $12 per head of the population. This would represent a capital of expenditure, allowing for double the population at present, of about two million dollars for works alone. He seemed to think that if the sewage could be got rid of satisfactorily by sea disposal for the same money that it would cost for any other system of local disposal, that it would be a better method to adopt, and save the cost of treatment.

He further considered that the chemical precipitation system as applied in Glasgow, was quite as economical as far as construction and maintenance were concerned as the septic system with filtration or other systems.

The Committee visited the sewage disposal works at Plainfield, N. J., in October, where the system adopted is septic tanks with double contact filters, the effluent discharging into the Essex Brook. They purify, however, only one million gallons per day.

This plant when completed with the necessary amount of filter beds will have cost about $80,000 and if the same proportion of cost was carried out in the case of Paterson, it would cost this community about two million dollars to build works sufficient for twice the population.

Following the Plainfield report was a report by Mr. Hewat, of a tour made in England, Ireland and Scotland, in conjunction with Mr. Whipple, Mr. Hazen's partner. This report is as follows :

"To the Joint Committee on Sewage Disposal.
Paterson, New Jersey.

Gentlemen :

I would report to you that Mr. Whipple and myself, for a further purpose of studying the sewerage systems as practiced in Europe, arrived in London on the 11th day of March, 1906, and on the next day commenced our investigations.

Mr. Whipple deserves great credit for the manner in which he had arranged his itinerary, as we were able, not only to see and converse with the principal engineers and authorities on the subject, but also to see and inspect many of the plants for sewage purification in the different places we visited.

We, for the first seventeen days, traveled together through England and Scotland, after which it became necessary to separate in order to divide our remaining time in investigations in Ireland and the Continent.

We have interviewed between eighty and ninety authorities on this matter in the time we have been away and have visited over twenty representative sewage plants.

Mr. Whipple conducted his investigations in a very thorough manner and will certainly give you ultimately the best advice upon this subject obtainable from investigation abroad and at home.

I have made some notes as we went along and submit them to you simply in the form of a diary. Conflicting opinion we found constantly among managers of sewage works, but this may have been due to local conditions and a difference in sewages; but the opinion of Sewage Inspectors and Medical officers of local Boards who were in charge of this matter was practically unanimous as to the best methods of disposal.

In summing up the points which appear more prominent in English practice are the following:

The principle of treating sewage when fresh seems pretty firmly established and septic tanks appear to have lost favor, on account of the nuisance due to smell, and on account of the small amount of sludge disposed of on this principle. Contact beds are considered no good at all, on account of the small amount of effluent that can be treated on a given area and the necessity of continuous cleaning and repairs; and trunk sewers do not seem to be in favor, owing to the necessity of having waters returned to the rivers throughout the country.

Simple chemical precipitation seems to be carried out with favor in the estuaries and where the tide water can take care of the further purification of the effluents, as in London, Dublin and Glasgow.

Raw sewage is emptied into an estuary, when the tide is sufficiently strong to carry it away, as at Liverpool and Edinburgh. In Belfast bay, where the sewage is put out on ebb tides, they have had great trouble, owing to the growth of sewage weeds and are now forced to put in purification works.

The best system of purification for the production of a good effluent on a large scale, as found was:

1st. Screening tanks.

2nd. Detritus tanks.

3rd. Sedimentation tanks in series, (from shallow tanks six feet deep to tanks twenty feet deep, with or without chemicals).

4th. Sprinkling filters, (about one million gallons per acre per twenty-four hours).

5th. Sedimentation tanks, (to catch remaining matter in suspension).

The amount treated per acre on sprinkling beds depends on the nature of the sewage. At Bradford was treated one quarter million gallons, at Birmingham three quarter millions and at Salford two million gallons per acre per twenty-four hours. During wet weather flow these figures might be doubled. In some cases we found these high rates did not give particularly good results.

The average cost of plants in England seems to be about $5.00 per head of population. The Salford plant costing $4.25 and the Chester $11.25, these being the extremes.

The necessity of experimenting with the sewage in a district in tanks and on filter beds we found could not be accentuated too much and will repay any trouble and expense taken in the end and avoid endless trouble.

The future disposal of mill effluents in Paterson will have to be gone into very carefully and considered as affecting the City domestic waste.

In England the law requires that mills pay to a town a sum per thousand gallons in proportion to the extra expenses incurred in the purification of the combined sewage as compared with the cost of purifying the City domestic sewage alone.

This cost we found varied from two cents to sixteen cents per thousand gallons.

The depreciation of property values in the neighborhood seems to be of importance and will be required to be figured out. The action of frost and snow on filter beds in a severe winter would prevent the rotary systems from being adopted.

The Riparian rights of the people below Paterson, as to the return in the future of all possible water to the river, should legislation affecting this question be forced, seems a point that this town ought to consider carefully.

Again, will the sewage here at one hundred gallons per head in Paterson, take any more area for purification than the sewage in England at twenty-five gallons per head? If it does not then a relatively smaller area would be necessary than the proportion of 100 to 25.

As a plant on which one might be modelled for Paterson, both as to results and as to the fact that many of the larger cities have or are gradually adopting this system, I might mention more particularly the Salford plant.

The population here is 230,000 or twice that of Paterson, and the system of purification, sedimentation tanks with chemicals, and fixed sprinkling filters.

Some of the details would necessarily have to be altered, nor is it certain that chemicals would have to be used here. The average daily amount of sewage treated throughout the year, including wet and dry weather flow, is twelve million gallons. Four hundred tons of sludge are removed to sea per day, 15 per cent. of which is solid matter. The sewage here is a mixture of mill waste and domestic, and is considered dense as compared with many others. Dye works, breweries, and tanneries are included in the system. The entire cost of the work here to date has been one million dollars, but'all their sewage is not finally treated at the present writing, as they were just finishing the necessary filter beds for this purpose. The area of these beds being eight acres and costing $30,000 per acre to construct.

The cost of running this plant per annum is $155,000, which includes all interest, etc., on investment. The cost of constructing the entire plant to date per head of population is $4.25, and of running the same per head about seventy cents per annum.

I would express my thanks to the following gentlemen who gave us valuable assistance:

Mr. A. B. McDonald, City Engineer of Glasgow.
Mr. James Barr, Consulting Engineer of Glasgow.
Mr. M. Fitzmaurice, Engineer of London County Council.
Mr. J. H. Tudebury, Sec. of the Inst. of C. E's.
Dr. McGowan, Mr. Willis and Mr. C. C. Frye, of the Royal Commission.
Mr. J. Corbett, Borough Surveyor of Salford.
Dr. Letts, Queens College Belfast.
Dr. Clowes, Chemist of London County Council.
Mr. I. D. Watson, Engineer of Birmingham Sewage works.
Mr. E. Halliwell, of the Ribbie Joint Committee.
Dr. Hope, Liverpool.
Dr. Tatton, Manchester.
Col. Kemp, Rochdale.
Mr. Jos. Garfield, Eng. of Bradford Sew. Works.
Dr. H. M. Wilson, West Riding of Yorkshire.
Dr. Travis, Hampton Sewage Works,

and the many others in Britain who extended consideration and courtesy to us in our investigations.

If Paterson has only half the population of Salford a reduction might be made on all these figures, after carefully finding out the quality of the sewage here; and unless it is found that the larger quantity of sewage, claimed to be produced by Paterson per day, is as difficult to treat as at Salford; when a consequent increase in these figures would occur; all of which matters are now being considered by the Engineer.

Salford, like Paterson, has no separate system of drainage.

The plan, as to laying out purification works, generally followed in England, is to provide tanks and filter beds sufficient for three times the dry weather flow, some system of storm filters, for between three and six times the dry weather flow, and to allow all over six times the dry weather flow to pass to the rivers without purification. My notes on interviews and inspection of plants are annexed to this to be disposed of by your Committee.

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Respectfully submitted,
HENRY J. HEWAT.

The second tour of the plants in New England was made at this time by Mr. Hazen, Mr. Young and members of the Committee who had previously not been there. Their reports were duly considered by the Committee in session, and followed, more or less, on the lines of the reports already made by the members who had visited the New England states previously.

## INSPECTION OF PASSAIC RIVER.

After duly considering all these reports the Committee determined to make a final examination and inspection of the Passaic river in company with the engineers. With this object in view they sailed down the river from Passaic Bridge, through Newark bay to the Kill von Kull, and inspected the proposed outlet for the trunk sewer at Robbin's Reef. The proposed trunk sewer outlet, in the Kill von Kull, was also considered. The Committee noted that immediately after passing the various towns large quantities of sewage gas were in evidence; that approaching these towns there did not seem to be any. This seemed to prove that great quantities of sludge are deposited on the river bed by these various communities, below the towns, and that septic action was taking place to a considerable extent in the river itself; thus proving that the tidal water was thoroughly inadequate to take care of the sewage. In Newark bay no perceptible trace of sewage was apparent. While at present in the Kill von Kull there does not appear to be any nuisance created by the sewage, presently entering from the communities on the sides of the water there, it is doubtful whether 300,000,000 gallons entering here, at one particular spot, might not create a considerable nuisance, if it were allowed to flow both on incoming and ebb tides. With regard to the Robbin's Reef outlet such a diversity of opinion exists among the engineers as to the probable nuisance that would be created by the Passaic Valley sewage if allowed an outlet at this point that it would be advisable to have the combined action of the New York and New Jersey Sewage Commissions to determine whether this outlet would be practical

## CONFERENCES WITH NEWARK RELATING TO TRUNK SEWER LEGISLATION.

On October 25th, 1905, the Board of Trade of the City of Newark sent a special invitation to the Joint Committee on Sewage Disposal to attend a meeting in the Free Public Library of Newark, which had for its purpose the advocating of the passage of enabling legislation for the commencement of work to secure the removal of pollution from the Passaic river, with a request that a statement be submitted on behalf of the City of Paterson. This Committee accepted the invitation and delegated Dr. R. M. Curts to make any statement that might be necessary. At this meeting Dr. Curts stated that the City of Paterson had no desire to construct any procedure which would remedy the existing condition of the Passaic river, and that we were at the present time endeavoring to make a careful investigation of the sewage problem so far as the City of Paterson might be involved, whether it would be by entering into a joint trunk sewer with the communities below us or by local disposal works, it remained for the Joint Committee of Paterson to decide. He, however, gave assurance that it was the policy of the City of Paterson to keep her sewage out of the Passaic river.

On February 17, 1906, the Joint Committee were invited to attend a meeting at the City Hall in the city of Newark to discuss a new trunk sewer bill. The Committee accepted the invitation and on arriving at the place of the meeting were informed that the bill had already been framed and that it was desired that the representatives of Paterson discuss the bill as a whole. Inasmuch as nearly every member of our Committee present had not recieved a copy of the bill up to the hour of meeting, it was clearly quite impossible to enter into any discussion of the same on its merits, and inasmuch as they were informed that the bill was to be presented on the following Monday they were obliged to state that, owing to the present conditions exisiting in Paterson, and the very limited time for examination of the bill they were unable to endorse it.

## THE WORK OF THE COMMITTEE CONCERNING TRUNK SEWER LEGISLATION DURING THE YEAR.

While the City of Paterson was making every effort to fairly do its part in seeking out a remedy for the existing conditions the Passaic Valley Sewerage Commission proceeded to introduce into the legislature a bill concerning the disposal of sewage for the Passaic Valley district, which bill contained, as we believed, many features which were inimicable to the interests of this city. The Committee, therefore, made extensive preparation to oppose and defeat any trunk sewer legislation during the last session of the legislature.

The City of Newark arranged for a special hearing before the Committee on Public Health, with the object in view of having the bill reported out and if possible passed by the Assembly and Senate. At this time invitations were sent to a large number of citizens to be present and oppose any efforts that might be made on the part of the City of Newark. The City of Paterson was represented by about one hundred of its citizens. The following memorial was presented by the representatives of Newark and the Passaic Valley Sewage Commission giving their reasons why the bill should be enacted as a law.

## ASSEMBLY, NO. 237.

STATE OF NEW JERSEY.
Introduced February 19, 1906.
By Mr. Martin.
Referred to the Committee on Public Health.

An Act to prevent the pollution of the waters of the Passaic river, between the Great Falls, at or near the City of Paterson, and the mouth of the said river at the Newark bay, prohibiting the discharge of sewage or other polluting matter into the said portion of the said river after a date fixed, and authorizing the municipalities from which sewage and other polluting matter is or may be discharged into the said river, between the said points, to enter into contracts with each other and with the Passaic Valley Sewerage Commissioners for the disposal of such sewage or other polluting matter, and to provide the necessary funds therefor.

Be it enacted by the Senate and General Assembly of the State of New Jersey:

1. Every municipality, corporation and individual of this State is hereby prohibited and forbidden to discharge, directly or indirectly, any sewage or other polluting matter into the waters of the Passaic river at any point between the Great Falls, in or near the city of Paterson, and the mouth of the said river at Newark bay, after the first day of May, which will be in the year one thousand nine hundred and ten; and the Passaic Valley Sewerage Commission, a body corporate, as now constituted, are hereby authorized and empowered to enforce the provisions of this act over and throughout all municipalities which may, or the inhabitants of which may, directly or indirectly, discharge sewage or other polluting matter into the waters of the Passaic river between the points above designated, after the first day of May, nineteen hundred and ten

The said Passaic Valley Sewerage Commissioners are hereby authorized and directed, within thirty days after the approval of this act, to notify each municipality from which sewage or other polluting matter is discharged into the said river between the said points, either directly or indirectly, and the inhabitants thereof, that the discharge of sewage and other polluting matter into the waters of the said river must be discontinued on or before the first day of May, in the year one thousand nine hundred and ten; such notice shall be in writing, signed by the president and secretary of the Passaic Valley Sewerage Commission, and shall be served upon the clerk or other equivalent officer of every such municipality, and shall be published in one of the newspapers printed and circulating in each of the counties of Passaic, Bergen, Hudson and Essex, for two consecutive weeks, one in each week, such public notice to be in the following form:

"To whom it may concern: Public notice is hereby given that the discharge of sewage and other polluting matter into the waters of the Passaic river at any point between the Great Falls, into or near the city of Paterson, and Newark bay is prohibited, and must cease and be discontinued after May first, in the year one thousand nine hundred and ten."

The Passaic Valley Sewerage Commissioners are further authorized and empowered to institute, in their corporate name, suits at law or in equity, as may be deemed necessary or appropriate, to enforce the provisions of this act, after said first day of May, in the year one thousand nine hundred and ten; and the Court of Chancery of this State is hereby vested with special jurisdiction to enforce the provisions of this act in a summary manner, upon application of the Passsic Valley Sewerage Commission, or of any individual corporation or municipality affected by the discharge of such sewage.

2. The common council or other governing body of any municipality or municipalities discharging sewage or other polluting matter into the said portion of the Passaic river, may, by resolution, determine that it is advisable and to the interest of such municipality or municipalities, in order to comply with the provisions of this act, to cause the sewage and other polluting matter discharging into the waters of the Passaic river, from its or their territory to be intercepted by a trunk or main intercepting sewer or conduit, and to conduct the same to a safe and proper place for its discharge and disposal, and there to discharge and dispose of the same; and may further, by said resolution, request the Passaic Valley Sewerage Commissioners to prepare and submit maps, plans and specifications for the construction of such trunk or main intercepting sewer or conduit, and of the necessary works for the discharge and disposal of its sewerage and other polluting matter at some safe and proper place, together with an estimate of the probable cost of such construction and of the operation and maintenance thereof, and of obtaining the necessary property and rights for the construction thereof; and also an estimate of the capacity required by each municipality discharging sewage or other polluting matter into the said portion of the Passaic river, directly or indirectly; also an estimate of the proportion of said cost of construction and maintenance, which should fairly be apportioned to each such municipality.

The municipality or municipalities making such request shall, in and by said resolution, agree to pay to the Passaic Valley Sewerage Commissioners the cost of preparing such maps, plans, specifications and estimates so required.

3. Upon the passage of such resolution by one or more of such municipalities, the said Passaic Valley Sewerage Commissioners shall forthwith prepare the said maps, plans, specifications and estimates, and submit the same to the governing body of the municipality or municipalities, requesting the same.

The governing body or board of such mnnicipality or municipalities shall thereupon submit the same to the governing bodies of the other municipalities discharging sewage or other polluting matter into the said portion of the Passaic river, either directly or indiectly, and thereupon, if said maps, plans specifications and estimates shall be approved by resolution of the governing bodies of municipalities to which the estimate made shall apportion one-half of the cost of said works, then the municipalities approving such maps, plans, specifications and estimates are authorized and empowered to enter into a contract in writing with the Passaic Valley Sewerage Commissioners, in their corporate capacity, for the construction, maintenance and operation of such intercepting sewer or conduit, and its appurtenances, together with the works, machinery, appliances and other things requisite or useful for the purposes to be accomplished by such intercepting sewer or conduit.

The contract hereby authorized shall generally describe the route, line, size and capacity of said intercepting sewer or conduit, and shall fix the percentage of the capacity therein, to the use of which each of the contracting municipalities shall be entitled, together with the percentage of the total cost and expense of the construction of the same to be paid by each contracting municipality; said total cost and expense to include the cost and expenses of the preliminary maps, plans, specifications and estimates.

The said contract shall provide for the construction of an intercepting sewer or conduit sufficient in size and capacity to intercept, discharge and dispose of sewage and other polluting matter of the contracting municipalities, so far as the same can be estimated and forseen for the future, and may differ substantially in its various details from the preliminary maps, plans, specifications and estimates approved of by the general contracting municipalities as hereinabove directed; and the several contracting municipalities are hereby vested with absolute discretion for determining the size and capacity of such intercepting sewer or conduit and its appurtenances

In determining the proportion of the expense of construction, maintenance and operation which each municipality shall assume and provide for, regard shall be had to the benefits which shall be conferred upon persons and property in each municipality.

In any contract made or entered into pursuant to the provisions of this act, it shall be lawful to provide for the repair, rebuilding, operation, maintenance and cleaning, and the cost and expense thereof, of any such intercepting sewer or conduit and its appurtenances.

In any such contract the several municipalities contracting with the Passaic Valley Sewerage Commissioners shall undertake and agree, upon the request of the said Passaic Valley Sewerage Commissioners, to exercise and put in operation their powers of eminent domain for the condemnation of lands or rights in land for the benefit of such joint enterprise.

Upon the making of the contract hereby authorized, the Passaic Valley Sewerage Commissioners shall have full power, in their own corporate name, to purchase and acquire all lands, rights and interest in lands which may be necessary for the construction of such intercepting sewer or conduit, and its appurtenances, and for this purpose are authorized to condemn the same in the manner provided by the general laws of this State relating to the condemnation of lands for public use.

Upon the making of such contract the Passaic Valley Sewerage Commissioners are further authorized and empowered to erect, construct, maintain and operate such intercepting sewer or conduit, and its appurtenances, together with all works, machinery, appliances and other things requisite or useful for the purposes to be accomplished by the same.

The compensation of the members of the Passaic Valley Sewerage Commissioners, together with the incidental expense of maintaining their corporate organization and all clerical and engineering services, and the reasonable compensation of counsel which they are hereby authorized to employ, shall be taken to be a part of the cost of construction of said intercepting sewer or conduit, and its appurtenances, and shall be apportioned to and paid by the several contracting municipalities.

It shall be lawful for the Passaic Valley Sewerage Commissioners, in the excecution of said work, to build and construct said intercepting sewer or conduit, and the necessary appurtenances thereof, to the point of discharge of disposal determined by them, and for this purpose to pass through, or partly through, territority situated within the bounds of any other municipality than those contracting with it for the construction of said work, and they shall have full power to construct such intercepting sewer or conduit, and its appurtenances, along, under or over any water course, or under or over or along or across any street, turnpike, road, railroad, highway or other way, or public park or grounds, and in or upon private or public lands under water, in such way and manner, however, as not necessarily to obstruct or impede travel or navigation, and may enter and dig up any street, highway or private or public land, for the purpose of constructing said work and appurtenances, and for repairing and maintaining the same, and in general may do all other acts and things necessary, convenient and proper in connection with the making and maintaining of the improvement contemplated by the provisions of this act.

Whenever any work to be performed or materials to be furnished in the performance of the said joint contract shall involve an expenditure of a sum of money exceeding five thousand dollars ($5,000.), the Passaic Valley Sewerage Commissioners shall award the contract for the same, after due advertisement, to the lowest responsible bidder; all contractors shall be required to give bond, satisfactory in security and amount, to the Passaic Valley Sewerage Commissioners.

5. For the purpose of defraying the cost and expense of the construction of such intercepting sewer or conduit, and its appurtenances, and of making the payments which shall be designated and required to be made by such joint contract, the governing body or board in charge of the finances of any such contracting municipality are hereby authorized and empowered to borrow the money necessary to make such payments upon the notes of other temporary obligations of such municipality, which notes or obligations may be renewed from time to time until permanent bonds shall have been issued by such municipality to pay the same.

Any such contracting municipality shall have the power and is hereby authorized from time to time to issue its bonds for the purpose of raising the money necessary to pay its notes or other temporary obligations issued and outstanding for the purposes hereinbefore stated, or to make any of the payments required by the said contract, which said bonds shall be in such amounts, and bear interest at such rate, not exceeding six per centum per annum, and shall be payable at such time and place as the governing body or board of such municipality shall by resolution duly adopted determine.

The total amount of indebtedness incurred and of bonds issued by any municipality under the authority of this act shall not exceed ten per centum of the tax ratables within such municipality as shown by its official books of the last assessment for taxes therein. but said indebtedness and bonds shall be held to be authorized in addition to the amount of indebtedness and bonds fixed by charter or general act as a limitation beyond which such municipality may not incur indebtedness or issue bonds, and said indebtedness and bonds authorized by this act shall not be taken to be included within or governed by any such limitation.

6. At any time after the making of a contract in accordance with the provisions hereof, the Passaic Valley Sewerage Commissioners, may, with the consent of the municipalities which have contracted with them, enter into a further contract or contracts with any one or more of the other municipalities discharging sewage or other polluting matter directly or indirectly into the said portion of the Passaic river, for the use of the said intercepting sewer or conduit and its appurtenances, and for participation in the benefits and cost of construction, operation and maintenance of the same, upon such terms and conditions as may be agreed upon in such contract or contracts, provided the payments to be made by such other municipality or municipalities shall be applied by the Passaic Valley Sewerage Commissioners, to the benefit of the original contracting municipalities, in proportion to the payment provided to be made by them under their contract with the Passaic Valley Sewerage Commissioners.

In case the moneys paid by such subsequent contracting municipalities, or any part of it, shall not be needed for the construction of the intercepting sewer, or conduit, and its appurtenances, the whole, or such portion of such payments as may not be so required, shall be paid over by the Passaic Valley Sewerage Commissioners to the municipalities originally contracting, in proportion to their shares of the cost of the construction of the said works.

7. Upon the making of any such contract herein provided for the Passaic Valley Sewerage Commissioners are authorized and empowered to borrow upon their corporate note or other temporary obligations, any moneys which may be required by them in the performance of the said contract, for the repayment of which moneys so borrowed, said contract with the several municipalities executing the same, shall be security.

8. Upon the completion of such intercepting sewer or conduit, and its appurtances, the Passaic Valley Sewerage Commissioners are authorized and directed to retain and have the sole control and charge of the said sewer or conduit and its appurtenances, and

in case the contract for the construction thereof shall not determine and apportion the cost of the maintenance and operation of the said intercepting sewer or conduit among the several municipalities using the same, the Passaic Valley Sewerage Commissioners are empowered to apportion such cost of maintenance and operation in such manner as may seem to them equitable and just, and every municipality using such intercepting sewer or conduit, is hereby required to pay to the Passaic Valley Sewerage Commissioners, on demand, its proportion of the cost of maintenance and operation, as the same may be certified to it from time to time by the Passaic Valley Sewerage Commissioners, which said cost of maintenance and operation shall be raised and provided for by the said municipalities by taxation, or by the issue of temporary loan bonds in anticipation of taxation.

9. In case for any reason any section or provision of this act shall be questioned in any court, and shall be held to be unconstitutional or invalid, the same shall not be held to affect any other section or provision of this act.

10. All acts or parts of acts inconsistent with the provisions of this act are hereby repealed.

11. This act shall take effect immediately.

## PASSAIC RIVER PURIFICATION.

### A MEMORIAL CONCERNING ASSEMBLY BILL.
### No. 237.

To the Senate and General Assembly of the State of New Jersey:

Gentlemen:

The joint committees representing the citizens, the Common Council, the Board of Works, and the Board of Trade, of the City of Newark, beg leave to present to you a statement of facts pertaining to the effort for the purification of the Passaic river, and invoke your aid, to the end that justice may be done to hundreds of thousands of people, representing hundreds of millions of taxable wealth, who demand that opportunity shall be given to abolish the pollution of that stream and remove the menace to health and prosperity which exists from this cause.

The first demand for river purification came from the city of Paterson. Its Board of Health condemned the foul condition of the river and urged the necessity for relief in 1895, and in the same year its Board of Trade appealed to the Newark Board of Trade to join in an effort to secure legislation to prevent further pollution.

Early in 1896 these bodies joined with the New England Society of the Oranges, and agreed upon a measure which was passed by the legislature of that year. This measure provided for the appointment of a special commission, and appropriated $10,000 to defray the expenses of an investigation. The commission reported in favor of the construction of a trunk sewer along the banks of the Passaic river, and presented a bill to carry their recommendations into effect.

Governor Griggs, a citizen of Paterson, in his annual messages of 1897 and 1898, urged with vigor the necessity for relief from the foul pollution of the river.

The State Sewerage Commission, in its first report, to the Legislature of 1900, favored the passage of a law to compel those polluting the river to make some other disposal of their crude sewage, and the Legislature passed an act prohibiting the emptying of sewage into the river after March 1, 1904, which was found inoperative because no other means of disposal had been provided.

Governor Voorhees, in 1900 and 1901, reviewed the problem in his messages and urged the adoption of measures for relief. In 1901 he placed at the disposal of the

State Sewerage Commissioners, from the emergency fund, the sum of $8,000 for an investigation. Such investigation was made with the aid of some of the most eminent engineers of the country, and the State Commission reported in favor of a trunk sewer from the southern boundary of the City of Paterson to an outfall in New York bay. Governor Voorhees, in 1902, urged upon the Legislature the importance of the passage of a law to carry this plan into effect.

Governor Murphy, in his inaugural message in 1902, considered the question the most important problem before the Legislature and urged prompt action. The Legislature of that year passed laws establishing the Passaic Valley Sewerage District, creating a commission to investigate its needs, and appropriating $25,000 to defray the expenses of such investigation.

This commission investigated the various sewerage systems of this country and Europe, together with all the known methods of sewerage treatment and disposal, and the application of all to the particular needs of this district. They reported to the Legislature of 1903 in favor of a trunk sewer from the Great Falls at Paterson to an outfall in New York Bay, and presented the conclusions which justified the plan, both as to its efficiency and economy. These conclusions were supported by eminent engineering authority.

The Legislature of 1903 then enacted a law providing for the prosecution of the work, under the same Commissioners. The work contemplated a sewer of sufficient capacity for the disposal of the sewage of a population of 1,600,000, or about three times the population of the district at the present time, at a cost not to exceed $9,000,000.

Under authority of this law, the Commissioners, proceeded to engage in actual work, but were stopped by litigation instituted by the City of Paterson, to test the constitutionality of the law. The Supreme Court sustained the law, but was reversed by the Court of Errors and Appeals. The latter Court, however, based its decision only on the manner of providing for the cost of the work.

For a number of years the City of Paterson has been the principal objector to the trunk sewer plan, without offering any other plan to meet its own needs, or the needs of the district. At the outset of their work, the present Commissioners provided hearings, which enabled each municipality interested to be heard in relation to the whole matter. Nearly all of the twenty municipalities, through their representatives, either favored the trunk sewer or expressed their willingness to accept the conclusions of the Commissioners. Paterson was the sole objector, but is has never had an alternative plan to present.

During the past four years it has been unceasing in its opposition, without offering something better. Yet it cannot allege that its interests have not had the fullest and fairest consideration. The plan of the State Sewage Commission provided for a trunk sewer from the southern boundary of the City of Paterson to the sea. The plan adopted by the Passaic Valley Sewerage Commissioners, provided for a sewer from the foot of the Great Falls, giving Paterson an intercepting sewer along its entire river front of more than six miles, at a cost of nearly one million dollars, or nearly two-thirds of its share of the whole cost.

Because of the plea of present financial difficulty urged by Paterson, provision was made in the law of 1903 that taxation for sinking fund for the bonds should not commence till five years after their issue.

That city has also tried to obstruct the work of river purification in various ways. When it raised the question that the general government might object to the laying of sewer pipes under the waters of Newark bay and the Passaic river, expert opinion to the contrary was obtained by the Commissioners from the highest government engineering authority.

When the law of 1903 was pending in the Legislature, Paterson, with greater solicitude for the people of New York than their neighbors of New Jersey, raised the contention about polluting the New York bay, and caused the proposed act to be so amended, that operations could not be commenced until it was ascertained that a nuisance would not be caused to persons and property in the State of New York. The Commissioners made exhaustive inquiry, and with opinions from eminent engineers who are familiar with the conditions in New York harbor, proved that under the plan proposed there could be no serious or offensive pollution which would affect the people of that State.

One effort was made by Paterson to show that a better plan in the interests of that city than the trunk sewer could be devised. Samuel M. Gray, of Providence, an engineer of national reputation, was employed at considerable expense to examine into the feasibility of a plan for the disposal of the sewage of Paterson independently and apart from that of any other municipality. Mr. Gray preformed his work and submitted his report. This report was never published, but it is known that it showed that a separate disposal plant would cost Paterson $2,670,185 for construction, while Paterson's share of the construction cost of the proposed trunk sewer was only about $1,500,000. It also showed that the annual cost for maintenance would be $207,135.20, while Paterson's share of the annual cost for maintenance of the trunk sewer would be less than $100,000,

From the outset Paterson has admitted the crying necessity for the purification of the river. In the actions for damages brought against that city for polluting the river by riparian owners below, Paterson has entered the plea that it intends to cease such pollution. But its unceasing contention has been that Newark and the other municipalities of the district affected have no right to force it into any plan of disposal which it does not approve.

With the health of their people menaced, their industries affected, and their material prosperity retarded, and tired of the unceasing opposition for ten years to all efforts for the accomplishment of river purification, Newark and other municipalities vitally interested have determined to ask the Legislature for authority to remedy their own offending, and to compel others to remedy their offending in such manner as they may deem best for their own interests. To this end they have introduced in the Legislature a bill known as Assembly Bill No. 237, which has been referred to the Committee on Public Health of the House of Assembly.

This measure provided that all municipalities shall cease polluting the river after May 1st, 1910, giving all ample time to provide such means of sewage disposal as they may choose. To this the city of Paterson cannot reasonably object, as it has admitted the great need for river purification. The proposed law then makes provision to enable such municipalities as may desire to do so, to enter into a contract with each other for the construction of a trunk sewer that will carry away their sewage which is now emptied into the river. No municipality is compelled to enter into this contract. Each is left entirely free to employ such method of disposal as it likes.

Simultaneously with this effort comes the announcement that Paterson has entered into another exhaustive investigation as to the best means for the disposal of its sewage, and wants the passage of this law delayed for weeks or months, until it can complete this inquiry. Meanwhile, the Legislature will have adjourned, and any remedy for the abatement of this intolerable nuisance will be postponed another year.

We submit to you that this excuse for delay is not a reasonable one. Before the contracting municipalities can enter upon their work, the Paterson investigation will be concluded, and that city and other municipalities will be in a position to know if it will be to their interest to join those who avail themselves of the trunk sewer proposition, or to provide separate means of disposal. No aid is asked from the State, no compulsion is laid upon any municipality to do aught than to cease polluting the river, and we hold there can be no good reason for the retention of this bill in committee, or valid objection to its prompt passage by the Legislature.

In the last annual message of Governor Stokes, he advised that the cities of Newark and Paterson get together in an effort to solve the great question of river pollution. The City of Newark has taken the initiative for the fulfilment of that request. Finding the city of Paterson unalterably opposed to the plan which commends itself to most of the other municipalities, we have devised a plan to solve the difficulty, which affects only those who voluntarily enter into the compact, and gives others an opportunity to join it later if they find it is the best.

Yet we are informed in various ways, and notably by a newspaper which professes to represent the sentiment of Paterson, that this bill is to be delayed in the committee to which it is referred—a delay which many fear may prevent legislative action during the present session.

We therefore appeal to you, the Legislature of the State, to accede to the request of a large portion of its population, which is hereby made, that this bill shall be speedily reported from the committee to which it has been referred, and that it shall be enacted into law without delay, for the relief of the municipalities that desire to avail themselves of its provisions.

We present this request because of the danger to public health arising from the constantly increasing pollution of this river. When the Chicago river was purified it was considered the worst polluted river in the country. That river, at its worst, was a mixture of one part sewage to four parts of water. In periods of low fresh water flow, the Passsaic river is one vast cesspool, containing at times 1,000,000,000 gallons of sewage to 2,400,000,000 gallons of water, making the proportion of sewage to water as 1 is to 2.4. This pollution is also greatly aggravated by the fact that the sewage remains in the Passaic, oscillating with the tide, from six to fourteen days in dry periods. It is in all probability, the worst polluted river in the world. The stenches sicken the operatives in the factories and the residents along the river banks, and prevent the development of a great residental district, convenient to municipal centers, and traversed by five railroads and numerous trolley lines. The increase in property valuations alone, as the direct result of cleansing this river, would in a reasonable period produce enough taxable revenue to defray the cost of this improvement.

We urge our request, also, because of the vast interests affected by this improvement. Within the eighty-one square miles of territory in the drainage area of the Passaic Valley Sewerage District there is contained a population of 675,000, and taxable wealth amounting to $340,000,000. The increase of population in this district in the last five years has been 77,367. At the present ratio of increase the population will exceed 1,000,000 in 1925. One cannot contemplate without horror the increased defilement of this river which must come from this growth of population if remedial measures are not at once adopted.

Municipalities representing three-quarters of the population of the district, and more than two-thirds of the taxable wealth, have practically assented to this proposed law, which enables them to accomplish their own part of this work, without entailing cost upon or in any way affecting the rights of other municipalities.

It is incomprehensible to us that any objection should be raised to, or obstruction be placed in the way of this righteous law, and we appeal to you to aid our just desire in the manner above stated.

In behalf of the people of Newark, represented by committees of its citizens and the legislative branches of the municipal government, we are

Most respectfully yours,
Henry M. Doremus,
Chairman.

John S. Gibson,
Secretary.

In reply to this the following memorial was prepared giving substantial reasons by the Joint Committee on Sewage Disposal of the City of Paterson, why such a bill should not be enacted at this session.

## RIVER PURIFICATION BILL.

### Paterson's Contention.

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## A MEMORIAL CONCERNING ASSEMBLY BILL NO. 237.

To the Senate and General Assembly of the State of New Jersey:

Gentlemen:

The Joint Committee of the Tax payers' Association and the Board of Aldermen of the City of Paterson, appointed for the purpose of ascertaining the best method for the disposal of the Sewage of the City of Paterson, beg leave to present to your honorable bodies a statement of facts pertaining to the attitude of the City of Paterson, as related to the question of the purification of the Passaic river. This statement of facts is intended to answer in as clear and concise a manner as possible a memorial presented by a like committee of the City of Newark, at a previous public hearing upon Assembly Bill No. 237, held March 5, 1906. Also to present for your consideration the reasons why the bill under discussion does not meet with the approval of the citizens of Paterson, and the reasons why the citizens of Paterson pray your honorable bodies, in order that justice may be done to all, to defer the final consideration of any bill for the purification of the Passaic river until the various municipalities financially interested can agree upon an equitable and satisfactory solution of the difficulty.

We pass over a review of the history of the purification measures which have been considered from time to time, claiming the credit for our city of having first, through our Board of Health, in 1895, advocated the purification of the river. We call attention, however, to the fact that even though we were as a city the first to suggest to Newark a consideration of this matter, we have neither, in the first bill prepared and introduced for this purpose, nor in any subsequent measure, had an opportunity to safeguard our city's interests, by assisting in the preparation of, or being allowed to make any suggestions in relation to, the character of any bill introduced; but have invariably, if called to a conference, been asked to assist in the passage of a bill which, being fully prepared and decided upon by one of the parties in interest, namely the city of Newark, left nothing to confer upon and everything to accept or reject. Is it then strange that up to and including the present bill rejection of the measure seemed to be the only course rationally open to our city?

We are charged with having persistently opposed all legislation offered in solution of the problem. We admit the opposition. We are also charged with offering no better solution of the difficulty—either for ourselves or others—although Newark admits that we made one ineffectual effort in the employment of Mr. Gray. That effort cost a few citizens of a private organization of the city of Paterson money, and was not a thorough and exhaustive investigation, and the investigation was not authorized by the city government. Paterson is now making an effort to solve the problem and in spending its own money, the Board of Aldermen having appropriated ten thousand dollars for the purpose, and appointed a committee who are honestly working to gain the knowledge necessary to offer to the citizens of Paterson a solution of the difficulty, whether it be a trunk sewer or a separate disposal plant.

The Engineer employed by the Committee is one of the best in the country.

The members of the committee are working faithfully. Our Mr. Hewat and Mr.

Whipple are at this time in Europe investigating the various systems there, and every system is to be investigated.

That is our position. What is Newark's position? Their investigations have all been made upon trunk sewer lines. Their engineers were employed to furnish trunk sewer plans and estimates. Their lawyers were employed to draw trunk sewer bill and every cent of the expenses Newark has undertaken was met by the State of New Jersey and not by the city of Newark.

When the engineer employed by the city of Paterson requests the plans, cross-section drawings and estimates of cost, in order that he may report upon the Trunk Sewer proposition, he is told by members of the Passaic Valley Sewerage Commission that he cannot have them, and the purile reason that some contractor may get hold of the figures is given. Then, in all fairness, how can we ascertain what the cost of our city's proportion of a trunk sewer is to be, or check the figures made possibly in other interests than ours?

If the Passaic Valley Sewerage Commission are so anxious to do what is for the best interests of Paterson and the whole Passaic Valley, why do they wish to conceal from our engineer the figures, and how is it that Paterson, being a party in interest to the amount of, according to the commission's figure, one million, five hundred thousand dollars, is not entitled to as full a knowledge of the subject as other municipalities? We do not charge that the Passaic Valley Sewage Commission is only interested in Newark and the consenting municipalities; but we call to your attention the possibility, of self interest being a strong factor, as indicated by the appearance of members of the Commission before the Legislative Committee in behalf of the bill, which furnishes the gentlemen with a lifelong office, the salary of which is to be met by the respective municipalities, most of whom have had no voice in the selection of this Commission.

The City of Newark has introduced this bill, Assembly No. 237, and begs for its immediate passage, claiming that it includes only in its action consenting municipalities and none other need join. The bill appears to be ambiguous. There is some question whether the provision that the consenting municipalities shall furnish all other municipalities with the plans, may not be construed as compulsory by the Passaic Valley Sewerage Commission, which may possibly be a court unto itself, with sufficient power to compel all municipalities to join. The jurisdiction of this Commission appears to be absolute, all that the consenting municipalities have to do is to furnish the money required, and the Commission will do the rest, in just exactly the manner they may think best.

The consideration of the bill as a whole, after a careful study would seem to indicate the following to be

## PATERSON'S POSITION.

Paterson admits that the Passaic River is dirty and ought to be cleaned, but denies that the condition of the river causes disease or is likely to result in epidemics of any kind.

Paterson does not know yet whether it is for her best interest to purify her sewage by herself or to enter a trunk sewer combination.

She is now studying this question with a view of determining what her wisest course may be. The result reached will clearly depend largely upon the disposition to be made of the sewage collected in the trunk sewer. For instance, if the sewage should be discharged from such a trunk sewer into the Newark Bay it is altogether likely that Paterson's share fairly apportioned of cost of a trunk sewer would be less than the cost to her of separate purification of her sewage. If the crude sewage is discharged into the New York Bay then the cost to Paterson might or might not be less than the cost of separate purification of her sewage. If the sewage after collection should not be discharged into either Newark Bay or New York Bay, but should be purified before being so discharged, it would seem reasonable that it would be better for Paterson to purify her own sewage at home rather than send it many miles in an expensive sewer to be treated at the end of the line.

Paterson, therefore, wishes to reserve decision on the question whether or not she shall enter a trunk sewer project until the possibilities of local purification and the cost thereof have been further investigated, and until the ultimate disposal of the sewage under a trunk sewer project shall have been determined with a reasonable degree of certainty.

As long as there is a considerable chance that Paterson's best interests will be ultimately served by entering a trunk sewer, Paterson is opposed to any legislation establishing such sewer on a basis which would not be satisfactory to her should she wish to join the movement.

Paterson believes that the bill now proposed is of this character.

She objects to it for a number of reasons, among which are the following:

1. Area Included. The bill should include the tributaries of the Passaic river within the distance specified as well as the main stream, and all such tributaries should be brought under the operation of any legislation now passed.

It would seem well to extend the area to be provided for to Little Falls, as the region between Great Falls and Little Falls is rapidly building up; and while this has not been considered in the past, Paterson believes that the time has now come when the area for which legislation is made should be extended to include it.

There should be no question as to the bill's including all territory in Bergen county adjacent to the river and its tributaries, and a bill to be satisfactory should be made perfectly definite upon this point.

2. Police Power. The bill confers upon the Passaic Valley Sewerage Commission police power to enforce in a summary manner the provisions of this act. This power is of an entirely different character from that which authorizes the main work of the Commission—namely, the construction and operation of a system of sewers.

Paterson believes it unwise to delegate police power to this Commission, and believes that the best interests of all will be served by leaving such power with those officers whose duty it now is to enforce the law.

3. Uncertainty as to the Distribution of Cost. The bill leaves the distribution of cost among the several municipalities taking advanvtage of the act, absolutely at the discretion of the Passaic Valley Sewerage Commission.

No principles to be followed in making the distribution of cost are indicated in the bill.

The action of the commissioners is not subject to review by any court.

Paterson believes that it would not be safe to entrust her interests absolutely and for all time to a commission over which she has no control.

4. No Arrangements for Redistribution of Cost in the Future. The bill provides that the proportionate amount of cost to be borne by the different municipalities is to be determined at the outset, and the proportion so determined will apparently continue as long as the sewer is used. Clearly this is not a just basis.

The different municipalities will grow at different rates. Those having large areas and small populations at the present time will naturally be assigned small proportions of the cost. In the generation or more for which the sewer will serve these communities will, no doubt, grow to have populations corresponding more nearly to their area. The proportion of the whole cost of the work which they should bear should therefore be increased as their proportion of the population and wealth of the district increases.

Paterson maintains that the proportionate amounts of cost to be borne by each municipality should not be determined for all times at the outset, but should be determined from time to time upon principles established at the outset and incorporated in the act; and such principles should be simple and certain in their operation, and adapted to meet all conditions which can be reasonably anticipated.

5. THE BILL PROVIDES FOR AN INDEFINITE CONTRACT. Paterson objects to the bill because should she avail herself of it, she would become irrevocably committed to the payment of large sums of money through a long series of years, while she would have absolutely no control over either the amount of money to be paid or the way in which it was to be spent. She believes that if she enters a joint enterprise for the purification of the Passaic River she should be a partner in the enterprise, having a voice in its management and owning an interest in the property, which apparently would not be the case under the present bill.

6. FAILURE TO PROVIDE FOR FUTURE DEVELOPMENTS. Paterson believes that a sewer constructed under this act will be but the first of a series of such sewers. The experience of Boston will be repeated. Boston first built a main drainage system; afterwards the North Metropolitan sewers were constructed; then the Charles river sewer; then a south high level sewer; and the end is not reached yet. The construction of trunk sewers will go on as long as the population of the district served continues to increase. It will be the same with the Passaic Valley. The system first built will meet the immediate requirements. As the population grows other sewers will be required, some of which future sewers can appropriately be at a higher level adapted to take the sewage from the greater part of the district to the point of disposal by gravity, for most of the district is high enough to allow this.

This is not something that will come up in the remote future. It is a certainty and something which can be anticipated within a reasonable length of time. The basis upon which the work is undertaken should be elastic enough and comprehensive enough to fully take into account these possibilities and to make that the interests of each municipality will be fully cared for and protected throughout such gradual development with increasing population.

7. CONSTITUTIONALITY. Paterson is in doubt as to whether the arrangement proposed is such as to meet the decision of the Court as to the unconstitutionality of the preceding act. She thinks that the Court may hold that contracts, made by a municipality for an indefinite term of years and for an indefinite sum of money, and for an indefinitely specified service in removing sewage, are not in reality contracts, but only a subterfuge to allow the Passaic Valley Sewerage Commission to tax the municipalities of the district, as the Court holds that they cannot, directly do.

8. NOT DEFINITE IN PLAN. Paterson objects to the bill because no definite plan is presented either for the construction of sewers or for the ultimate disposal of the sewage.

Paterson believes that a bill which she could support should be more definite in character, and that all essential features of the propose scheme should be reasonably well established before the project is undertaken.

Paterson would petition your honorable bodies to grant them the time required to complete their present investigation for the reasons heretofore given. No proposition for the care of such large quantities of sewage, entailing the expenditure of nine million dollars or more, has been carried to a solution without the expenditure of years of time in its consideration and in the adoption of the necessary plans. In this country there has been no sewer constructed of the magnitude of the proposed Passaic Valley Trunk Sewer, in which so large a number of municipalities were to co-operate.

Paterson takes this opportunity to call your attention to the possibility, that the result of the work of the Flood Commission and of your newly appointed Water Commission may afford relief by a re-establishment of the natural flow of the river during the dry season.

The city of Paterson has been deprived of the natural flow of the Passaic river by the diversion of large quantities of water. In 1893 the sewage of the city of Paterson was not appreciable in the water at Belleville. The water of the river was then used by the cities of Newark and Jersey City and was considered potable water; since then the river has become offensive.

In behalf of the citizens of Paterson we humbly pray your honorable bodies to retard precipitant action on this important question in order that unanimity on the part of all the municipalities interested may in due time result in satisfactory legislation.

John Johnson,
Mayor.

Robert M. Curts,
Chairman.

William S. Ackerman,
Secretary.

## CONFERENCE OF REPRESENTATIVE CITIZENS OF NEWARK AND PATERSON RELATING TO THE WITHDRAWAL OF THE TRUNK SEWER BILL.

The successful efforts in opposition to any legislation led to what has been styled "a peace conference." The city of Newark and others interested in her contention realizing that further efforts on their part to force legislation would be futile and with a desire to enter into friendly relations with this city, with the hope of dealing with the sewage problem in a manner which would meet with the satisfaction of all concerned, proposed a conference in this city. Consequently, on Thursday, March 15th, 1906, the following gentlemen representing the city of Newark, Joseph Coult, Chandler W. Riker, J. Henry Bacheller and William P. Martin, and Gen. Jos. W. Congdon, Mr. Chas. N. Sterrett, Dr. R. M. Curts, Michael Dunn, Mayor John Johnson, E. G. Stalter, William I. Lewis, Vivian M. Lewis and former Judge Van Cleve, representing the city of Paterson, met in the Hamilton Club in this city and entered into a full discussion of all of the question which had involved the city of Newark and the city of Paterson in a dispute during the last ten years. The gentlemen of Newark, still hopeful of enacting legislation, offered generous concessions as to amendments that might be made in the bill before the Committee of the House of Assembly. The Mayor of Paterson, together with the City Counsel and the Chairman of the Joint Committee on Sewage Disposal, stated that it would be impossible for the city to enter into any agreement concerning the bill before the House until such a time as the Joint Committee on Sewage Disposal had rendered its report. It was finally agreed that the city of Newark would withdraw her trunk sewer bill and await the report of this Committee. It was further agreed that a special session of the legislature would be called in September, 1906, for the purpose of passing a bill which would be satisfactory to Paterson, and that in the event of Paterson joining with the other municipalities of the Passaic Valley District that the cost of construction and maintenance should be proportioned according to the ratables of the various municipalities interested aud that it was desirable that such a bill should be framed by representatives of the cities of Newark and Paterson.

Following this conference, the Mayor of the various municipalities of the Passaic Valley Sewage district, together with representative citizens, held an audience with the Governor of the State on the 19th day of March, 1906, at which time after presentation of the amicable settlement, the Governor made the following statement:

"Now, as I understand the matter the situation is this: The agreement is that the bill now before the Legislature, introduced by Assemblyman Martin, is to be withdrawn; that Paterson agrees that the report of its expert engineer as to the proper method of settling the question so far as Paterson is concerned will be made by September 1, and that if, in his report, Mr. Hazen favors a trunk sewer, *Paterson is to join with Newark in drafting a bill that will be mutually satisfactory.* But if Mr. Hazen favors some other solution of the problem, Paterson will probably adopt his suggestion and will then offer no further objection to Newark's efforts to secure the passage of some such bill as that now pending * * * *."

At this point Mayor Johnson interrupted to say:

"It is understood that if Paterson should decide to join in the trunk sewer plan *it must be in accordance with a bill drawn by all the communities jointly and not by Newark alone.*"

After the conference at Trenton, Mayor Johnson announced the result of the conference in a proclamation printed in the Paterson papers, the essential features of which were as follows:

## TO THE CITIZENS OF PATERSON.

"By virtue of an agreement reached at the conference * * * to discuss the trunk sewer, Newark will withdraw the bill which is now pending in the Legislature.

Paterson has reached an agreement with Newark by which this city gets until next September to complete its investigations of the most practical plan for the purification of the Passaic river; which will give Engineer Hazen ample time to make his report.

At the expiration of that time, Paterson will join with Newark in asking the Governor to call a special session of the Legislature, to consider a special bill to do away with the pollution of the Passaic river."

## LEGAL OPINIONS.

Mr. Hazen, early in the investigations addressed the following letter to the Committee and asked that a reply be sent to him.

Paterson, N. J., January 22, 1906.

MEMORANDA OF QUESTIONS FOR THE CITY COUNSEL.

Whether the City of Paterson has the power to take, by eminent domain, land for the purpose of building sewege purification works within the city limits.

Whether the city has the right to secure such land by private purchase, if arrangements therefor can be made.

Whether the city has the power to take land in Passaic County by eminent domain, for the purpose of building sewage purification works.

Whether the City of Paterson has the power to purchase land in Passaic County, for the purpose of building sewage purification works.

Whether the City of Paterson has the power to take land in the State of New Jersey outside of Passaic County, by eminent domain, for the purpose of building sewage purification works.

Whether the City of Paterson has the power to purchase land in the State of New Jersey outside of Passaic County, for the purpose of building sewage purification works.

Whether in case the City of Paterson does not now have the authority to take or purchase land in any or all of the above mentioned cases, the legislature could grant to the City of Paterson the necessary authority to acquire land in the above stated ways and in each of the areas mentioned.

This letter was referred by the Committee to Mr Stalter, the City Counsel, who, after considering the matter, replied as follows:

(Office of City Counsel.)

Feb. 14, 1906.

To WILLIAM S. ACKERMAN, ESQ.,
Secretary of the Joint Committee on Sewage Disposal,
Paterson, N. J.

Dear Sir:

Seven questions have been submitted for legal investigation by your committee relative to the powers of the City of Paterson in connection with the construction of sewage purification works.

I have investigated the different statutory enactments of the State of New Jersey relative to these matters, and I will answer your several questions in the order they were submitted to me.

I find that there are two acts which seem particularly applicable to our condition; one is entitled "An Act to allow towns, villages. or other municipal corporations to acquire and use lands or real estate in an adjoining township or municipal corporation for use for the construction of a sewage receptacle or sewage disposal works," approved April 9, 1892, found on page 452 of the General Public Laws of 1892.

This is a short act, and provides in section one that it shall be lawful for the governing body of any municipality to secure by purchase or condemnation or otherwise in any municipal corporation, the necessary land and real estate for the erection or construction of any sewage receptacle or works or place for treating or disposing of the sewage, etc., of said municipality.

Section 2 provides that before preparing said land or real estate for the disposal of he sewage or house waste of said city where said land or real estate is in a municipality other than the one constructing the works, it shall be necessary to secure the consent by a resolution of the governing body of said municipality within whose boundaries such lands are located; such resolution must receive the votes of the majority of members of such governing body.

This act renders possible the answering in the affirmative of the first six questions submitted by your committee. I would say, however, that the act is not complete, because it provides nothing beyond the mere elementary steps, there being no provisions made for the cost or the actual operation of the necessary work.

The second act to which I referred above is entitled, " An Act to provide for drainage and sewage in cities of this State," approved April 7, 1890.

This act was amended by an act passed in 1894. Under the provisions of these two acts the city has the power to construct a system of sewerage and drainage whenever the owners of at least one-half in value of the real estate in said city as shown by the assessor's books, shall petition the Board of Aldermen so to do. This act takes up the entire matter, and seems to provide for the very conditions which now face your Committee.

The first section, however, which requires a petition from the owners of at least one half in value of the real estate in said city, seems to me to be almost prohibitory. The remaining portion of the act, however, treats the matter in a very systematic way.

Section 7 further provides that in case the governing body shall deem it expedient to collect the sewage of the city or of any part thereof from any sewer or sewers constructed under the said act or any other act of the legislature of the State, and to deodorize, utilize, condemn or dispose of the same by sale or otherwise, wholly or in part it shall be lawful for said Board of Aldermen to purchase lands in the corporate name of the city, and to erect all necessary buildings, works and machinery thereon, and to take and appropriate for such purpose any lands and real estate upon making compensation to the owner or owners as hereinafter provided.

Section 8, provides that when an ordinance has been passed directing the construction of a sewage system under this act, that all further acts and proceedings necessary to be taken may be by resolution and not by ordinance.

Section 9, provides that the ordinance for making this sewage improvement shall not be acted upon until public notice has been given as in said section provided.

Section 10, provides that the Board of Aldermen, after the passage of such ordinance shall appoint by ballot from their own number a committee to be called "The Committee on Sewers," which shall have charge of the work under the supervision of the said Board of Aldermen. The section goes on to provide for the details of such work.

Section 11, provides that whenever the Board of Aldermen shall have determined by ordinance to construct any sewage receptacle or pumping station, or other structure or work for treating or disposing of water or sewage, and shall deem it necessary to take and appropriate for any such purpose, any lands and real estate either within such city or beyond its limits, they are hereby authorized to treat with the owner or owners thereof for the same, and may purchase said lands and real estate.

Sections 12, 13, 14 and 15, provide for a method of condemnation where no agreement can be made for the purchase of said lands.

The remaining sections of said act take up the matters of assessment of damages, the issuance of bonds, and other matters of detail to carry out the provisions of the act.

Your committee will see by reading over the acts above mentioned, that one provides for the elementary steps in the procedure, while the other provides a complete system with the exception of the prohibitory clause in section one.

As to the last question submitted, the Legislature can grant any further powers that are necessary for the completion of the work, providing such powers are not prohibited by the constitution.

Very truly yours,
EDMUND G. STALTER,
City Counsel.

These same questions were referred to Mr. Michael Dunn, and he replied as follows:

Paterson, N. J., June 7th, 1906.

MR. WILLIAM S. ACKERMAN, Sec'y.
Paterson, N. J.

Dear Sir.

I have looked into the questions received from you, and regard the present legislation as being in a very unsatisfactory condition to effectually accomplish or bring about the results suggested by the questions. I will take them up in order and indicate my view on the same.

ANSWER TO FIRST QUESTION. It would be difficult to answer this question in the the affirmative without making an explanation. The Board of Aldermen are given the power under the act approved March 8, 1882, P. L. 1882, p. 60, to construct sewers, to provide, maintain and alter a general system of sewerage and drainage for such city to establish and maintain one or more outlets or places of deposit within or without such city, for sewerage or drainage, and to provide for the disposal and drainage from the city, and to repair and cleanse such sewers and drains.

You will observe, by the language used, that the city has the power to provide a place for the disposal of sewage, and under this Act it is also provided that the city can exercise the power of eminent domain in constructing a sewer across private lands, but I have not found any express power given to the city to condemn lands for a disposal plant.

ANSWER TO SECOND QUESTION. I have no doubt but that the city has the right, under the law stated above, to obtain lands by purchase for the disposal of its sewage. The infirmity in the provisions of the Act of 1882, cited above, is that there is no provision made therein authorizing the issue of bonds by the city to pay for the purchase of such lands and the erection of necessary buildings thereon. The right to do so must be implied from the fact that the city is given the power to supply such a plant.

ANSWER TO THIRD QUESTION. The answer to the first question is practically a response to this question. I do not think the city has the power to take lands in Passaic county by eminent domain, to build a sewage purification works.

ANSWER TO FOURTH QUESTION. This is covered by the answer to the second question above. The city can obtain such lands by purchase.

ANSWER TO FIFTH QUESTION. I do not think that the city, by eminent domain, now has the power to take lands for the purpose of building a sewage purification works outside of Passaic county.

ANSWER TO SIXTH QUESTION. In view of the language used in the first section of the

Act of 1882, and also in an act passed in 1905, P. L. 1905, p. 54, I am of the opinion that the city can buy lands outside of Passaic county for the purpose of building a sewage purification works.

Answer to Seventh Question. The Legislature can authorize the city to take or purchase land in any or all of the cases mentioned. If unable to purchase the same it can vest the city with the power of eminent domain for the purpose.

Remarks. The legislation now existing on this subject in our state does not seem to have contemplated the conditions which now present themselves to us for solution. It will not be difficult to obtain such legislation, that may be necessary for this purpose, but the law would have to be general and applicable to all cities, and should necessarily contain some specific provision for the raising of the money necessary for the work, and provide some method by which bonds issued for the same could, in due time, be redeemed. The method to be pursued in this respect is a matter of detail, to be worked out by the counsel who may be entrusted with the drafting of the bill.

Very respectfully,
Michael Dunn.

When Mr. Hazen was appointed as engineer to advise and report to the Joint Committee on the question of sewage disposal for the city of Paterson; the question of the extent of his investigations of the various methods of disposal was gone into, and ultimately he was instructed by the Committee, that, instead of merely considering purification systems, his field of investigation was to be unrestricted, and would include every method including that of sea disposal. Holding this in view, it seemed to this Committee, that the following legal points ought to be definitely settled, before any scheme of disposal, which in the end might be recommended, could be said to have been thoroughly and intelligently considered.

(1). Regardless of the system to be ultimately adopted, how is money to be raised to execute the work; and by what method are bonds to be issued for the same, and in due time, redeemed?

(2). How is land to be acquired for the right of way for any main sewer, for any particular plan of disposal that may be adopted? This involves not only land within the city limits of Paterson, but without the city limits, in the County of Passaic or other counties of the State of New Jersey, or land in an adjacent State.

(3). How is the land to be acquired, upon which a local disposal plant could be erected, either within the city limits of the City of Paterson, or without said limits in the County of Passaic or other counties of the State of New Jersey, taking into consideration the fact that such a plant might not border on the limits of the City of Paterson?

(4). Can sewage from part of or the entire population of the Passaic Valley be discharged into Newark Bay with or without purification in the event of a sea disposal system being recommended?

(5). Can sewage from part of or the entire population of the Passaic Valley be discharged into New York Bay with or without purification in the event of a sea disposal system being recommended?

(6). In the event of the adoption of a sea disposal system, where all the sewage and manufacturing wastes are taken directly to sea, how would the diversion of the waste water from Paterson affect the condition of the river in dry weather, taking into consideration the Riparian rights of the people below Paterson, situated on the river, and those who might require the water for manufacturing or other purposes; would the town suffer from action for damages in such case, on the plea that all possible water should, if taken from the river, be returned to the river after the best possible purification?

(7). How is the proportion of the expense of the construction and maintenance of a local disposal plant to be distributed amongst those who contribute sewage to such a plant in large quantities; and at what quantity, if any, would a line be drawn, where the admission of trade wastes to be treated, should be so treated without expense to their producers; or would it be more economical for the town to treat all wastes and sewages, irrespective of the individual quantities and qualities without special charges?

These questions were answered in the following manner by Ex-Attorney-General Griggs, in reply to a communication addressed to him by Mr. Henry Hewat:

June 21st, 1906.

HENRY HEWAT, Esq.,
Paterson, N. J.

Dear Sir:

I have received from you seven questions for reply as to their legal phases in connection with the subject of sewage disposal for the city of Paterson, which the committee, of which you are a member, now has under consideration. In some respects the questions call for opinions as to matters of fact, and, as to these matters, I have not assumed to give any opinion. As to the legal questions involved, I answer your questions seriatim as follows:

QUESTION ONE. The method in which money shall be raised to carry out any system of sewage disposal adopted by the city of Paterson is one to be construed as a practical financial matter in connection with such legal knowledge as would be ordinarily required in any such matter. I assume that the expense would have to be paid by the city at large, and that bonds would have to be issued to raise the money, and a sinking fund provided for their redemption.

QUESTIONS TWO AND THREE. The city of Paterson has at present no legal authority to acquire lands for such a system of sewage disposal as you are considering. It would be necessary to have such authority conferred upon the city by an act of the Legislature, which I assume would not be difficult.

QUESTION FOUR. If authorized by the legislature to empty sewage into Newark bay, the city of Paterson would be exempt from public prosecution for a nuisance, but might become subject to suits for injunction or damages if the sewage washed up upon the shores injuriously affected the riparian owners. Riparian owners upon tidal waters have no special rights in the waters or lands thereunder, such as belong to riparian owners on non-tidal streams, or upon fresh water streams above the flow of the tide, but riparian owners on tidal streams are entitled to have their property protected against nuisances created by the discharge of refuse which washes up upon their banks.

QUESTION FIVE. In my judgment, the discharge of sewage by the Passaic Valley into New York bay would be subject to restraint at the suit of the city of New York, provided it created an injurious nuisance. There are other lawyers, however, who have the opposite view.

QUESTION SIX. The only persons who could claim any injury from the diversion of water under the circumstances mentioned in this question, would be the riparian owners above the Dundee dam, and their damages would be slight and inconsequential.

QUESTION SEVEN. This is hardly a subject for legal opinion, but a question of practical administration. It would seem just that those who make large and extraordinary use of a disposal plant should be required to pay more for its cost and maintenance than those who use it slightly. For instance, a gas company and a dye works which contribute so largely to the pollution ought to pay more than an ordinary householder.

Respectfully submitted,
JOHN W. GRIGGS.

These same questions were answered in the following manner by Mr. Michael Dunn, in reply to a communication addressed to him by Mr. William S. Ackerman.

ANSWER TO FIRST QUESTION. Issuing of bonds to be redeemed by assessment for special benefits, or by general tax.

ANSWER TO SECOND QUESTION. The land needed for this purpose must be acquired by the power of eminent domain, to be secured from the Legislature by additional legislation. If the land is needed in a foreign state the consent of the Legislature of both states would be necessary.

ANSWER TO THIRD QUESTION. Additional legislation.

Answer to Fourth Question. Yes, with consent of state, but you would be responsible for damages caused by nuisance.

Answer to Fifth Question. Yes, within the territorial limits of our state, with legislative consent, subject to being responsible for damages to private property and to reasonable police regulations of New York state over the bay.

Answer to Sixth Question. As to the water supplied to the city and its inhabitants by the Passaic Water Company, under their contract with the city, I do not think the lower riparian owners could make any complaint against the city. Once this water is taken from the river and sold, it becomes the property of the purchaser to use as he may see fit. If more injury would be caused by the diversion than is being now suffered, it would seem that the riparian owner would have to look to the diverter and not to the city.

The riparian owner would have no claim to the water pumped from artesian wells and now being discharged into the river. That and the water purchased from the Water Company belongs to the man who buys or pumps it, to dispose of as he may see fit.

Water pumped by the factories directly from the river, and not again returned to the river, might be made a basis of a claim if the riparian owner could show any substantial injury in consequence.

The power plant of the Dundee company would undoubtedly be diminished, and it would be entitled to compensation. The plan adopted would necessarily provide compensation for such cases. I know of no other power. The effect, if any, on navigation in tidal water should be considered.

Answer to Seventh Question. The proportion of the cost of construction and maintenance paid is a matter of detail, to be worked out and agreed upon by the municipalities interested. This also applies as to what treatment is to be given to factory waste.

## These same questions were answered by Mr. E. G. Stalter, city counsel, as follows:

(Office of City Counsel.)

July 18, 1906.

To the Joint Committee on Sewage Disposal
of the city of Paterson.

Gentlemen:

Seven questions have been submitted to me by your Committee covering the legal points involved in the disposal of the sewage of the city of Paterson.

I herewith respectfully submit my answers to the same.

No. 1. The system of sewage that is adopted by your committee necessarily has some bearing upon the question of raising money. If you adopt a system of sewage disposal separate and distinct from any other community, corporate bonds of the city of Paterson would have to be issued for a long term of years, and a sinking fund established for the redemption thereof at maturity. The cost of construction and the expenses of maintenance, operation and repairs would necessarily be kept separate. The former being met by the bond issue aforesaid, and the three latter by an annual appropriation in the tax levy. These matters would, of course, have to be provided for by legislation.

If a trunk sewer system should be adopted which embraced several distinct municipalities, the question of raising money by bond issue would be an entirely different matter. The act passed in 1903, which was subsequently taken to the Court of Errors and Appeals and decided to be unconstitutional, provided for a method of raising money by bonds issued by the District Sewage Commissioners. This was one of the points of unconstitutionality, and by reference to this case, a lengthy and elaborate discussion of this question may be found.

No. 2. Land may be acquired for the right of way of any main sewer, and for any particular plan of disposal, either by purchase or condemnation. This, of course, would have to be provided for by legislation, and consent would have to be obtained from the governing body of any other municipality for the erection of a disposal plant within the limits of that municipality, and outside of the limits of the city of Paterson. If a trunk sewer were built, the district Commissioners would, of course, be given the powers of condemnation, and that would be paramount to the rights of the different municipalities through which the sewer might pass and for whose benefit the sewer is built; but with a disposal plant for the separate use of the city of Paterson, we cannot enter upon the lands of another municipality without first obtaining the consent of the governing body of the municipality in addition to purchasing or condemning the rights of the individuals owning the lands. We would have no right to occupy or use the lands of an adjacent state without the consent of that state.

No 3. This question has already been answered by the answer to No. 2.

No. 4. In reply to question No. 4, it is my personal opinion that crude sewage without any purification, cannot be discharged into Newark bay, if a nuisance is thereby created. In other words, any person who has rights that are injuriously affected, could, by injunction, stop any further discharge.

No. 5. In answer to your fifth question, I would report also that it is my personal opinion that crude sewage without any purification cannot be discharged into New York bay, if thereby a nuisance is created. To my mind it makes no difference whether New York city empties its sewage at different points into the bay. One unlawful use does not legalize another unlawful one and I have no hesitation in saying that any private individual whose rights are injuriously affected, would be able to enjoin any further discharge. The State of New York might also interfere with such a discharge, and the United States government might interfere.

Both questions, No. 4 and 5, are very important factors in any plan for a joint trunk sewer. These questions are very broad in their scope, and you may find much diversity of opinion in the answers to them. The matter is so important, however, that judicial decisions should be obtained before any expenditure of so large a sum of money should be made where possibly no use can be made of the works for which the money was spent.

No. 6. In regard to question No. 6, the first part of the question is largely one of an engineering nature. I would say from a legal standpoint, however, that any riparian owner along a fresh water stream has a right to the full and uninterrupted flow of the water, and if he is deprived of this to his damage, the municipality or person depriving him would be liable for damages.

No. 7. Question 7 involves matters of an engineering nature. I would say, however, that manufacturers have no right at the present time to empty their trade wastes directly into the river. Consideration, however, should be given to the fact that these manufacturers contribute largely to the welfare of the city of Paterson, and no system should be adopted that would become so burdensome to them as to possibly drive them out of the community. The effect of these trade wastes upon the plan of purification would also have a large bearing upon this question.

Very respectfully,
Edmund G. Stalter,
City Counsel.

In further review of the difficulties met in the proposed discharge of sewage of the Passaic Valley District into Newark Bay, and the consequent sludge deposit, we would submit the following opinions of the War Department and State Sewerage Commission covering the question of emptying raw sewage into Newark Bay.

Subject. Sewer; Great Falls, Paterson to Newark Bay, N. J.
War Department,
Washington.
File No. 7616 June 17, 1897.

Sir:—In response to your letter of March 24, 1897, submitting report and printed plans of the Commission proposing the construction of a trunk sewer from the Great Falls at Paterson to Newark Bay, New Jersey, I have the honor to transmit herewith copy of a report on the subject from the New York Harbor Line Board, dated May 28, 1897, which embodies the view of the Department on the question presented.

Very respectfully,
R. A. Alger,
Secretary of War.

Mr. William T. Hunt,
For the Commission to consider a plan
of Sewerage for the Passaic River,
Globe Building,
Newark, N. J.
(Inclosure: 5 of 7616)

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Subject: Passaic Valley Sewage.
HARBOR LINE BOARD.
New York City, May 28, 1897.

Brig. Gen. John M. Wilson,
Chief of Engineers, U. S. A.,
Washington, D. C.

General:

In compliance with instructions contained in 6th indorsement, dated April 12, 1897, upon a letter from the Passaic Valley Sewerage Commission to the Secretary of War, dated March 24, 1897, having reference to the question of the possible interference with navigation of the plans for sewage disposal proposed by the Commission, the New York Harbor Line Board has the honor to submit the following report:

The plans proposed by the Commission, which are described in detail in the printed report accompanying its letter above referred to, contemplate the discharge of all the sewage collected in what is called the lower Passaic district upon the flats of Newark bay at a point about 2,200 feet above the bridge of the Central Railroad of New Jersey. The Board is required by your instructions to examine and report upon the question of the the probable effect of the scheme upon the navigable capacity of Newark bay and adjacent waters.

The navigable channels which would be affected by the proposed scheme of sewage disposal are the channel of the Passaic river between Passaic and the Centre street bridge in Newark; the channel extending from Centre street bridge in Newark to deep water in Newark bay; and the channel on the south side of the bay connecting the Arthur Kill with the Kill von Kull. The conditions in these channels are briefly as follows:

**Channel Above Newark.** This channel extends from Centre street bridge, Newark, to the city of Passaic. The United States has expended $140,000 upon its improvement since 1872, and the work is still in progress. The project provides for a channel from 200 to 50 feet wide and from 7½ to 6 feet deep at mean low tide.

**Channel Below Newark.** This channel extends from deep water in Newark Bay to Centre street bridge, Newark. Between 1880 and 1886, the United States expended $170,000 in improving it to a width of 200 feet and a depth of 10 feet at mean low water, and the annual cost of maintenance has been $16,000.

**CHANNEL BETWEEN THE ARTHUR KILL AND THE KILL VON KULL.** This forms a part of the channel separating Staten Island from the state of New Jersey, which is seventeen miles long, extending from Perth Amboy, N. J., and Tottenville, S. I., to Constable Point, N. J., and New Brighton, S. I. The waterway is generally narrow, having a least width of about 500 feet. Its original depth was at least 15 feet at low water, except for a length of about 1¾ miles opposite the mouth of Newark Bay, where the depth was 9½ feet in a narrow channel bordered by flats. This channel has been improved by the United States by deepening the passage across this shoal; and further improvement is contemplated. The project provides for the formation and maintenance of a channel between the Arthur Kill and the Kill von Kull, 400 feet wide and 14 feet deep at mean low water, at an estimated cost of $210,000. The annual cost of maintenance is estimated by the district engineer at $10,000.

The channel connecting the Arthur Kill and the Kill von Kull is commercially of much greater importance than those extending through the bay, up the Passaic river, the traffic of the former in 1895 having been estimated at 9,865,000 tons while that of the latter was only 1,259,000 tons.

According to the report of the Sewerage Commission, the quantity of sewage now daily discharged into the Passaic river is about 75,500,000 gallons, of which about 49,500,000 gallons enter the river below the Dundee dam, and about 26,000,000 gallons above it. The sewage entering the river below the dam must increase the rate of shoaling in the channel and thereby increase the cost of channel maintenance. The material entering the river above the dam is doubtless deposited in the upper part of the river and in Dundee Lake, and can have little or no effect upon the navigable channel which terminates below the dam. The plan of the Commission proposed to discharge all this material into Newark bay whence it may be moved by the currents into navigable channels, thereby increasing about 50 cent. the quantity available to produce shoaling.

Should the outlets for sewage discharge be removed from the river to the bay, as proposed by the Sewerage Commission, the effect in the channel of the Passaic river would probably be to diminish the rate of shoaling; but the Board is of the opinion that, owing to the location of the new outlet and the increased quantity of the material to be discharged, the rate of shoaling would be increased in the channel between the mouth of the river and deep water in Newark bay, especially at the lower part.

The most important question, however, in connection with the proposed plan of sewage disposal is its probable effect upon the channel connecting the Arthur Kill and the Kill Von Kull. As has been before remarked, the commercial importance of this channel is vastly greater than that of the others. It will, under any circumstances, require more or less dredging for its maintenance. The Board is of the opinion that the concentration and discharge of all the sewage of the lower Passaic District at a point only 1¼ miles from this channel cannot fail eventually to seriously increase the rate of shoaling therein Such an increase will not only augment the cost of dredging, but will also prolong the time during which the channel must be obstructed by machines.

From natural causes incident to the partial antagonism of the flood currents flowing into the southern end of Newark bay from opposite directions, the navigable channel leading to Elizabethport has always been subject to shoaling, requiring annual expenditures, of greater or less amount, for maintenance. These effects are clearly apparent in the wide shoals in the vicinity of Shooters Island and the Corner Stake Light.

The estimated annual deposit of 650,000 cubic yards of solid material in the lower end of Newark bay following the adoption of the proposed sewer system, would fill up the entire area of the bay below the proposed sewer outlet, from bank to bank, to the depth of about one-third of a foot annually, if evenly distributed.

As the existing average depth of the flats, except in the narrower width of the improved channel, is about four feet at mean low water, it is easy to see that it will require only a few years to make the proposed sewer system not only a public nuisance but a serious obstruction to the navigable waters adjacent to the Harbor of New York.

The Board is of the opinion that, as a general rule, when it is desirable to discharge sewage or other material into tide water, it should be done at points where natural deep water exists, and not in the vicinity of artificial channels which require periodical dredging for their maintenance. Newark Bay is a land-locked tidal basin of considerable area, with comparatively small outlets, through which it will always be difficult to maintain channels of a depth adequate for navigation. The Board is of the opinion that it is not advisable to permit the use of such a basin as the receptacle for a large and constantly increasing amount of sewage. Even if the dilution of the sewage, for which provision is now contemplated, should be sufficient to prevent serious deposits, it is certain that the amount to be discharged will rapidly increase and eventually produce shoaling in the channels. The Commission recognizes the fact that this sewage cannot be indefinitely emptied into the waters of the bay, and that a time will come when other means must be adopted for its disposal.

The Board concurs in the opinion of the district engineer that the disposal of the sewage of the lower Passaic district in the waters of Newark bay will be detrimental to the interests of navigation.

Respectfully submitted,
Henry M. Robert,
Colonel, Corps of Engineers.
G. L. Gillespie,
Colonel, Corps of Engineers.
C. W. Raymond,
Major, Corps of Engineers.
H. M. Adams,
Major, Corps of Engineers,

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July 12, 1906.

Honorable William H. Taft,
Secretary of War,
Washington, D. C.

Sir:

On March 24, 1897, a report and printed plans of a Commission proposing the construction of a trunk sewer from the Great Falls at Paterson to Newark bay, New Jersey, was submitted to your department for consideration.

The Harbor Line Board reported on the subject to your Department which in turn transmitted to Mr. W. T. Hunt a copy of the report with the endorsement of your Department of the views as expressed by the Harbor Line Board. (Your file No. 7,616).

I beg to inquire if the conditions as they now exist in Newark bay would cause your Department to alter the views as expressed in the above report, i. e., "The Board concurs in the opinion of the District Engineer that the disposal of the sewage of the Lower Passaic District in the waters of Newark bay will be detrimental to the interests of navigation."

I understand the above opinion to refer to the disposal of raw sewage in the waters of Newark bay.

What degree of purification of the raw sewage would, in your opinion, be necessary in order to pass an effluent into Newark bay between the Kill's Light and Shooters Island, which would not be objectionable to the interests along the Kill von Kull or detrimental to the interests of navigation.

Allow me to be,
Very respectfully yours,
W. S. Ackerman,
Secretary.

War Deparent,
Washington,
August 3, 1906.

19109
Sir:

I have the honor to acknowledge the receipt of your letter of the 12th ultimo, in which you call attention to War Department action of March 24, 1897, refusing the Commission appointed to consider a plan of sewage for the Passaic river permission to construct a trunk sewer from the Great Falls at Paterson to Newark bay, N. J., and ask to be advised whether existing conditions are such as to cause the department to alter the conclusions above referred to; also, what degree of purification of the raw sewage would be satisfactory for passing an effluent into Newark bay, between Kills Light and Shooters Island.

Replying thereto, I beg to inform you that the Chief of Engineers, U. S. Army, to whom the matter was referred, reports under date of 1st inst, as follows:

"This paper was referred to Colonel Livermore, the district engineer officer, who stated in third endorsement hereon, that the matter has been under investigation by his office, and that he sees no reason for modifying the conclusion reached in 1897. I concur in this opinion.

"With reference to the further inquiry of the writer, as to what degree of purification of the raw sewage would be necessary in order to pass an effluent into Newark Bay, which would not be detrimental to navigation interests, it may be said that the degree of purification should be such that the effluent should not carry any solid matter which would produce shoaling; and, in this connection, it may be added that Section 13 of the River and Harbor Act of March 3, 1899, makes it unlawful to discharge any refuse matter of any kind into a navigable water of the United States, other than that flowing from streets and sewers, and passing therefrom in a liquid state.

Very respectfully,
The Military Secretary,
Acting Secretary of War."

Mr. W. S. Ackerman, Secretary,
Joint Committee on Sewage Disposal,
Paterson, N. J.

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August 1, 1906.

W. S. Ackerman, Esq., Secrerary,
Joint Committee on Sewage Disposal,
Paterson, N. J.

Dear Sir:

The State Sewerage Commission directs me to say in reply to your inquiry of July 12, 1906, as to the degree of purification necessary, in the opinion of the Commission, in order that affluent from the Passaic Valley trunk sewer might be discharged into Newark bay without causing objections on the part of the government or adjacent property owners, that this matter is one in which this Commission has no jurisdiction. As at present advised, however, it is the opinion of this Commission that no such effluent should be put into Newark bay which is in a condition which would easily permit of putrescibility. The Commission considers that the sewage to be discharged should be of such stability that it would not lose color by the methyl blue test within five days. An effluent so purified, would not, in the opinion of this Commission, cause objections either from the government or the riparian owners.

Respectfully yours,
Boyd MacLean,
Secretary.

## CONCLUSIONS.

The question of emptying of raw sewage into the New York bay is at the present time under consideration by The Metropolitan Sewerage Commission of New York and the New Jersey State Sewerage Commission, these commissions having been requested by the Governors of New York and New Jersey to act jointly; the object being that they shall endeavor to devise a method whereby the pollution of New York bay shall be prevented, through the joint and harmonious efforts of the two states. The time set for the report of the Metropolitan Sewerage Commission by an act passed by the Legislature of the State of New York on April 10th, 1906, is February 1st, nineteen hundred and nine.

The contention is, that the State of New Jersey has an equal right with the State of New York to empty its sewage into the waters of the New York bay. The report of these commissions will be awaited with interest.

The Committee cannot see how it can further solve this problem, as the ultimate policy with regard to the treatment of sewage in New York bay, would appear to rest with the State Commissions on Sewage of these states, and therefore it appears necessary to the Committee to accentuate the necessity of immediate consultation with Newark and the other communities interested so that immediate steps can be together taken, to make further action clear—in the case of discharging in New York bay.

It cannot be too forcibly noted that any trunk sewer scheme appears to this Committee, from what they know about such schemes of discharging raw sewage in other bays, merely a temporary expedient which may reduce the expense of the city of Paterson for sewage disposal for some time, but which system will ultimately have to be changed to purification.

When this Committee was first organized it was assured by a member of the Passaic Valley Sewerage Commission that all of the maps, plans and data of the Commission would be placed at the disposal of this Committee.

After the employment of Mr. Hazen, he was referred to Mr. John S. Gibson, Secretary of the Passaic Valley Sewerage Commission for all information regarding the trunk sewer.

Mr. Hazen in a series of letters written to Mr. Gibson and Mr. Rudolph Herring, the engineer of the Commission, was unable to obtain definite data in relation to the materials to be used in the construction of the sewer, the thickness of the wall, the shape of the sewers, cross-section drawings, materials to be used in submerged lines, nor the schedule showing the way in which the estimated cost of the sewer was made up. He did, however, receive permission to make blue-print copies of the drawings relating to the plan and profile, also a table which was not previously printed, showing the length of each section of the trunk sewer.

Mr. Herring said, "Details which did not materially affect the problem, other than to get the best general solution and the approximate cost, were properly postponed until after the work was authorized, then the details would naturally have to be worked out."

"The Commission does not desire me to give you the information for which you ask, as to shape, thickness of walls and materials of construction, nor of the itemized cost, preferring that you should use your own independent judgment, so as to act as a check to its own estimate of cost."

In view of this situation of affairs Mr. Hazen was obliged to make his own computations as to the cost of a trunk sewer.

Following the return of Mr. Whipple and Mr. Hewat from Europe, Mr. Whipple offered to give an illustrated lecture, showing and describing the various sewage works visited while abroad. This very interesting and instructive exhibition was given in the Council Chamber of the City Hall on May 16th, 1906: The public were invited to attend.

## PUBLISHING REPORT.

At a special meeting of the Joint Committee, held on July 12, Mr. Hazen's report, together with appendixes, was presented.

The report was read and the Committee passed the following resolution :

Moved by Mr. Ackerman, seconded by Alderman Young, that Mr. Hazen's report, the appendixes and maps, be referred to the sub-committee on report, with authority to have same printed.

Unanimously carried.

The sub-committee on report made application to the Board of Finance to further increase the appropriation of the Joint Sewage Committee so that additional copies of the report might be printed, to which they received the following reply:

Thursday, July 26, 1906.

W. S. ACKERMAN,
Secretary Joint Sewerage Committee.
Dear Sir:

At a meeting held yesterday, July 25, 1906, the Board of Finance decided not to further increase the appropriation for the Joint Sewerage Committee, so as to print additional copies of the report about to be issued.

Respectfully yours,
JOHN J. BROPHY,
Clerk.

At a special meeting held July 31, 1906, after further discussion of the report of the Engineer, it was resolved that the report be received and that the Aldermanic Committee make arrangements for a special meeting of the Board of Aldermen, to which the Taxpayers' Association were to be invited—at which time the Engineer's report should be presented.

On the eighth of August, a special meeting of the Board of Aldermen was held, and Mr. Hazen's report was presented. After some discussion the meeting adjourned to August 13th, 1906, at which time, by resolution of the Board of Aldermen, the report of the engineer was received.

In consequence of a temporary dissolution of the Joint Committee the fact that no action was taken by the Board of Aldermen to approve of a semi-official discussion with the other municipalities of the terms of the proposed trunk sewer bill they are not able to report authentically upon the probability of the acceptance or rejection of all or any part of their recommendations by other parties in interest, nor can they determine what the attitude of other municipalities may be in relation to the recommendations which are offered for the purpose of safeguarding the interests of our city. The Committee were anxious to enter into a consideration of and assist in the preparation of a proposed trunk sewer measure in order that the conditions of the bill proposed should be definitely known at this time, and that an intelligent comparison of the benefits to be derived from a trunk sewer project might be made, as related to the advantages to the city of Paterson of a local disposal plant. The Committee's warning now is that before this matter is seriously discussed and before a final decision is reached by this city, either in favor of a trunk sewer or a local disposal plant, that the draft of the proposed trunk sewer bill should be made by representatives of the different municipalities in interest, and that it should not be kept secret, but given wide publicity immediately, in order that before its presentation to the legislature it may be thoroughly considered and the necessary provisions made to safeguard the interests of all.

The Committee has considered the report of the Flood Commission and the theory of Dr. Calhoun in relation to impounding and using the headwaters of the Passaic in the dry season for the purpose of further diluting the sewage. In view of the fact that the Legislature by recent act has joined the Flood Commission and the Riparian Commission for the purpose of investigating this matter, and in view of the fact that our engineer has reported adversely to the efficacy of this plan for a continued period of time, and pending the above Joint Commissions' report, we refrain from making any further suggestions.

It is desirable that the City of Paterson, through its governing body, shall establish special policing of the river for the purpose of preventing pollution from stables, privies, garbage plants or any other source of contamination. It has been observed that livery stables situated on the banks of the river deposit considerable refuse into the stream, and that the stream is a common receptable for all sorts of garbage, ashes, papers, dead animals, etc., from the residences along its banks.

We believe that before any sewerage bill is presented to the Legislature the City of Paterson and the District should secure a release from the Dundee Water Power and Land Company for any diversion of water through the operation of any plan of sewage disposal.

The State Sewerage Commission in its report to the Legislature of 1906, refers to the proposed trunk sewer and contends that there should be state supervision of such work ; State interests are involved ; the communities outside the district are concerned as to the discharge of the sewers, and the relations of the state to other states, and to the Federal Government are affected.

"State authority should therefore have a voice and this Commission is the natural board for such control."

It would seem to the Joint Committee that if this contention be true, State aid might reasonably follow State control.

In Great Britain financial aid is given to any and all communities engaging in such public projects.

The Committee endorses the plans of Mr. Hazen in relation to the method to be adopted for the construction of a local sewage disposal plant, in case the Aldermen and citizens should ultimately decide to care for the sewage through local disposal works.

## RECOMMENDATIONS.

1. We recommend that Paterson join with the city of Newark and other municipalities in an effort to secure the disposal of sewage by discharging it into the sea without treatment, other than screening.

2. We recommend that the City of Paterson in conference with the other municipalities shall participate in the drafting of a bill for the purpose of securing legislation having the following provisions:

a. That the bill shall contain a provision that the trunk sewer shall discharge into tidal waters, and that the sewage discharge shall receive no treatment except rough screening.

b. That the time for cessation of river pollution shall be not less than five years from the date of the passage of the act.

c. That a district be created, including the territory between Dundee Dam and Little Falls and the lower part of the Saddle River watershed.

d. That the financing of the project be provided for by assessing the different municipalities in accordance with the ratio of the valuations of the ratables of each district to the valuation of the ratables of the entire district, both for construction and maintenance; and that at stated intervals the Commission shall re-assess the different municipalities in accordance with the increase or decrease of the valuation of their ratables.

e. That the bill be so drafted that in case of failure of the plan recommended of allowing the screened sewage to be directly emptied into tidal waters without other treatment, that it will be possible for Paterson, or any other municipality to withdraw and provide their own local disposal works, and such municipality or municipality withdrawing shall not be responsible for any expense other than their pro rata share of the expenses already incurred to the date of their withdrawing.

f. That the bill should provide for the appointment of a new commission for the district to consist of seven members, no more than three to be appointed from the same county.

g. That all police powers should be left in the hands of the present constituted legal authorities.

h. That there shall be a proper check on moneys expended by the Commission, and that the Commission shall be responsible to the appointing power, and to the governing bodies of the several municipalities in interest, to whom they shall make a financial statement of their expenditures annually, and whenever requested to do so.

i. That the district shall not be assessed for or required to pay any moneys which may have been expended by any commission previous to the passage of the proposed bill.

j. In case Paterson or any other municipality should withdraw and have its own local disposal plant, that part of the district wherein such plant or plants are situated shall be placed under the jurisdiction of the State Sewerage Commission.

k. That the question of State aid be considered.

l. That the trunk sewer shall be so constructed as to provide for the present flow of sewage and storm water, including the manufacturing wastes of the City of Paterson.

m. That the bill shall contain provisions permitting the City of Paterson, or any other municipality, to secure land by the right of eminent domain in the State of New Jersey for the purpose of the erection and maintaining of sewage disposal works, in the event of withdrawal from the trunk sewer project.

n. That the bill shall contain a provision for the city of Paterson, or any other municipality to adequately finance any project for the local disposal of its sewage—whether the sewage is disposed of jointly or separately.

3. That as a matter of expediency the Board of Aldermen and the Taxpayers' association, in joint session, have a committee appointed at once to take up the matter of sewerage legislation with Newark and other municipalities, in the consideration of a bill that will be fair and equitable to the City of Paterson.

COMMITTEE OF THE TAXPAYERS' ASSOCIATION.

ROBERT M. CURTS, M. D.,
VERNON ROYLE,
HENRY J. HEWAT,
WALTER B. JOHNSON, M. D.,
WILLIAM S. ACKERMAN, M. E.

COMMITTEE OF THE BOARD OF ALDERMEN.

DAVID YOUNG,
CHARLES W. MORGAN,
GEORGE A. FISCHER,
JOHN BOYLAN,
JOHN J. DOWNEY.

# REPORT

OF

# ALLEN HAZEN

TO THE

# Joint Committee on Sewage Disposal

PATERSON, N. J.

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JUNE 30, 1906.

# REPORT OF ALLEN HAZEN TO THE JOINT COMMITTEE ON SEWAGE DISPOSAL.

June 30, 1906.

To the Honorable,
The Joint Committee on Sewage Disposal,
City of Paterson, N. J.

Gentlemen:

I beg to present the following report as to the best means of disposing of the Paterson sewage so as to effectively prevent it from polluting the Passaic river.

Briefly the problem is to investigate local conditions, and to find the best method of purification, and then to find whether it is better for the city to adopt this method or to join with other cities in the construction of a trunk sewer to a distant point of discharge in sea water.

In this report I shall state the main points of the investigations which you have ordered, and my recommendations and reasons for them; but all detailed descriptive matter will be put in appendixes accompanying this report, which will, I belive, contain all the information which you have ordered or require.

**Investigations Made.** In making these investigations it has been necessary to study the whole art of sewage purification as now developed. To do this, with members of your Committee, the two largest sewage purification works now in use in this country, the Boston harbor outfalls and other points of interest were visited.

A member of your Committee, Mr. Henry J. Hewat, and my partner, Mr. G. C. Whipple, visited a large number of representative sewage purification works in Great Britain, and a few upon the Continent, and a detailed report of these works is appended. (1)

Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, and in charge of the Lawrence Experiment Station, where the longest continued and most exhaustive experiments upon this subject have been made, was employed to give advice and assistance with reference to the type of plant best adapted to purifying the Paterson sewage; the sizes of the different parts; and the means to be taken for handling the manufacturing wastes. Mr. Clark's report upon this subject is appended. (2)

(1) Appendix No. II; page 35.
(2) Appendix No. III; page 77.

I have made surveys of sites available for purification works; of the outlets of the present city sewers; and have combined the information thus obtained with data from the City Engineer, Mr. Harold J. Harder, and from other sources.

Mr. Whipple and Mr. Clark have been allowed to visit various manufacturing establishments, and a full study of the process of silk manufacturing has been made with reference to the volume and character of the wastes produced, and their effect upon the various works considered. (1)

A personal examination has been made of the whole route of the trunk sewer, and of various obstacles on its line, and of the proposed outlets. Estimates of cost for various projects have been made, based on such outline plans as were necessary to reach them.

I beg to express my obligation particularly to Mr. Hewat, member of your Committee, to Mr. Harder, City Engineer, and to Mr. Colin R. Wise, County Engineer, for courtesies and information received; and I wish also to express my obligation to very many manufacturers and dyers for permissions to visit their works and find out as to the wastes produced, and for information as to the various processes connected with their business, all of which data have been invaluable. In fact, this report could not have been prepared without this co-operation.

## POPULATION.

The populations of Paterson, as shown by recent census reports, were as follows:

| | |
|---|---|
| 1880 | 51,031 |
| 1890 | 78,347 |
| 1900 | 105,171 |
| 1905 | 111,529 |

Average growth per year, 3.2 per cent.; per decade, 36 per cent.

In the last twenty-five years, in the whole region about New York city, the average rate of growth has been three per cent. per year on the New York side of the Hudson river, and three and one-half per cent. per year on the New Jersey side, but in the last years the rates have come nearer together. (2) On the whole, the growths have been very uniform. For the purpose of this investigation I shall assume a rate of growth of three per cent. per year, equal to 34.4 per cent. per decade, both for Paterson and for the whole Passaic Valley district. It is impossible that this rate should

(1) Appendix No. I; page 3.

(2) A more detailed statement in Appendix No. XVII, page 139.

be permanently maintained, but at the present time there is no immediate indication of a falling off, and it seems best, therefore, to use this figure uniformly in making computations.

**Proportion of Population** Connected with sewers. Most of the population of Paterson is now connected with the present city sewers. Some of it is served by vaults. I have consulted the records of the City Board of Health, and have obtained data and estimates from other sources. From the best information obtainable I estimate that 89 per cent. of the population is now connected with the city sewers. (1) This proportion will gradually increase as vaults are discontinued.

**Adjacent Territory** To be considered in connection with Paterson sewers. Paterson is a small city in area. Near it is much territory not supplied with sewers, upon which population is increasing, so that sewers will be demanded in the not distant future.

The area tributary to the Passaic river between Dundee Dam and Little Falls is about forty-nine square miles. Eight square miles are represented by the city of Paterson, with a population of 111,529 ; and there are forty-one square miles outside, with a population roughly estimated at 22,000. In addition there are several square miles of the lower part of the Saddle river watershed which will require consideration. This territory outside of Paterson is building up rapidly, and its population will probably grow more rapidly than that of the city itself. Various railroads and trolley lines run through it. There are desireable locations for manufacturing establishments and for residences. (2)

There are no public sewers in this territory at the present time, although some parts of it have advanced to the point where sewers are almost necessary. It is certain that many sewers will have to be built within the next few years. The natural outlet for the greater part of this territory is through the city of Paterson, and substantially all of the forty-one square miles mentioned would most naturally drain to the Paterson sewers. The parts most requiring sewers are those immediately adjoining the city of Paterson. Separate sewage purification works cannot be used because such works would have to be located in the city of Paterson, or close to the city limits at places where the development is now such as to make the location of sewage disposal works inadmissible. Practically the only way in which this adjoining territory can be sewered is through the Paterson city works; and any system built now, whether by the city of Paterson or by a Joint Sewerage district, must be designed so as to take care of the sewage from such parts of this outlying territory as may be necessary. The present population of the whole district is about 133,000.

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(1) Appendix No. X ; page 111.

(2) More detailed description of this area in Appendix No. XV, page 133.

It must be rigidly insisted that all extensions of the sewerage system to new areas, whether within the city limits or outside of them, shall be upon the separate system. With this done, it is not important, so far as the purification works or the trunk sewer project are concerned, whether the whole of the population assumed in making computations is within the city limits or whether a part of it is in the adjoining territory. Further discussion of the probable location of the population to be provided for is therefore unnecessary at this time.

The cost of building sewers in the outside territory and connecting them with the works of the city of Paterson should clearly be borne by the population benefited. On the other hand, it is inevitable that this sewage will ultimately be mixed with the Paterson sewage, and this population must therefore be taken into account in determing the size of those parts of works which are not easily enlarged.

**Allowance for Future Growth.**

Taking into account the present population of the city, the population of the adjoining territory which will soon require sewers, the proximity of Paterson to New York City, and the extent and prosperity of its manufactures, I consider that works now built should be capable of treating the sewage from a population one-third greater than that shown by the recent census, or of 150,000 people, which population is to be anticipated at the assumed rate of growth in 1915. There will be no economy in building works smaller than this. A much larger population must be anticipated within the period for which works are now built, and I think it prudent to design everything so that the works can be doubled, making them sufficient to serve a population of 300,000, which will be reached by Paterson alone in 1938, and by Paterson, with the surrounding country, in 1933, at the assumed rate of growth. Those parts of the works first built, which are not capable of being readily enlarged, should be built of the full size.

This is looking far enough into the future. When this amount of growth has taken place it must be expected that other, larger and more adequate works will be required, whatever scheme may be adopted at the present time.

Estimates are actually made for somewhat smaller works. This is done, as will be shown later, for the purpose of making the estimates strictly comparable with those for the trunk sewer.

## MANUFACTURING WASTES. (1)

The manufacturing wastes are greater in volume than the domestic sewage of Paterson. They add materially to the pollution of the river. An adequate treatment of these wastes is an essential part of any plan for the purification of the river. Some of these wastes are now discharged through the city sewers, but most of them are discharged directly to the river. It will be necessary to arrange that all injurious wastes now discharged into the river shall be discharged into the sewers, or otherwise disposed of.

**Wastes From Silk Dyeing.**

In the dye-houses of Paterson are handled every year about seven and a half million pounds of raw silk, or two-thirds of the whole amount manufactured in the United States. In handling this material the dyers estimate that 1,000 gallons of water are used for every pound of silk, or, for working days, more than twenty million gallons per day, or 200 gallons per capita for the entire population. The actual quantity of water is no doubt smaller than this estimate, but it is certainly far greater than the public water supply.

Through the kindness of a number of silk dyers Mr. Whipple has secured numerous samples of representative wastes from the different processes. Information as to these matters is confidential and for this reason it is not produced in the appendixes of this report.

For every pound of raw silk a pound or more of soap is used. In the larger works the greater part of this is recovered, but a substantial proportion passes off with the wastes. A large amount of extractive matter, or gum, is removed from the silk. This matter is putrescible and contributes in a substantial degree to the pollution of the river.

Various chemicals and dyes are used in the process of dyeing. The object is to put as much upon the silk and as little in the river as possible, but there is necessarily a great deal of loss. Some of the substances used in greatest quantity are mineral, and do not contribute materially to the pollution of the river. Others do contribute to the pollution, and the waste dyes are conspicuous by their color, and objectionable principally because of it.

Of the injurious and polluting substances by far the greatest quantity is carried by a comparatively small volume of concentrated liquor, not exceeding five, or at most ten per cent. of the total volume of water used in the dyehouses. Certain further quantities of discharge contain some polluting materials, but the great bulk of the discharge consists of wash-water, containing only mineral substances, or organic substances, in such small quantities that they do not pollute the river.

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(1) A more detailed statement as to wastes is given in Appendix I, page 3.

These wash-waters are far cleaner organically than the river water now is, or is ever likely to be. In fact, some of them are purer organically than the river was in its natural state before it received any sewage. This is because a considerable proportion of the water used in the dyehouses is ground water obtained from the gravel and rock under the city. This water often contains much mineral matter, but is origanically pure. When surface water is used in dyehouses, either from the Passaic river at the Falls or from its tributaries, it is often, or usually, filtered before use, and the filtration is such as to remove a large part of the organic matter contained in it. The water used in the dyehouses thus is water of considerable organic purity. By far the greatest part of the discharges consists only of this water mixed with mineral matters. Such waste are free from organic constituents, and the mineral matters are not of such a nature as to pollute the river. Many organic wastes are too dilute to pollute the river appreciably.

It is, therefore, unnecessary and undesirable to attempt to carry away in a trunk sewer, or to purify, more than a small fraction of the total volume of the dye-house liquors. If the separation could be accurately made it would suffice to remove from the river about five per cent. of the total volume, or one million gallons per day. Owing to the difficulty or impossibility of effecting accurately such a separation, the amount actually to be taken care of will, perhaps, be double this quantity.

A few smaller dye-houses are not upon the river bank. From these, apparently, it will be necessary to take the whole amount of waste to the disposal works with the sewage. When a separate system of sewers is installed, at some time in the future, it will be possible to run some of the wash-waters from these establishments to the storm-sewers, but this matter has not been taken into account in making the calculations.

**Slaughter Houses.** There are three slaughter-houses and packing establishments, employing seventy-five men. Wastes from these should be dried and utilized for the most part. Those which cannot be so used must be discharged into the sewers.

**Breweries.** There are six breweries, making 230,000 barrels of beer and ale annually. Brewery wastes should be sent to the sewer. They have considerable polluting power, but offer no special difficulty in sewage purification.

**Other Dyeing.** There are two printing and dyeing establishments dyeing other materials than silk. Both are comparatively small. The larger one now discharges to one of the city sewers ; the smaller one directly to the river. This would require connection with the sewers. The amount of wastes from these establishments is not great enough to be a serious element in the problem.

**Silk Throwing Waste.** The waste from silk throwing consists principally of a solution of olive oil soap with some extractive matters from the silk. This waste is small in amount when compared with those produced in dyeing. Silk throwing is now mostly done in Pennsylvania. Only a comparatively small part of the silk used in Paterson is now thrown in the city.

**Gas Works Waste.** At the present time the gas works perhaps, contribute more to the offensive condition of the river than any other single establishment. The wastes are not discharged at all times, but at intervals, and they give rise to an oily, irridescent appearance upon the surface of the water, and to pronounced and disagreeable odors. It would be possible to discharge these wastes to the sewer, but it seems clearly better to treat them locally at the gas works. Appendix IV, page 83, contains a description of suitable works for rendering these wastes inoffensive.

**Summary as to Manufacturing Wastes** Taking into account all the data collected, I estimate that the manufacturing wastes of the city will add 25 per cent. to the volume of the sewage to be treated, and that the material added is, on the whole, considerably more difficult to treat than domestic sewage. Taking the sewage as it will be with the mills connected with the sewers to the extent above indicated, I estimate that the difficulty and expense of treating the sewage will be increased fifty per cent. because of these wastes, and all estimates are made on this basis.

**Other Studies in Manufacturing Wastes.**

The above was deduced entirely from information secured from the mills and from analyses of manufacturing wastes. In addition to these, analyses have been made of the river water at various places above and below the city. (1) For this purpose average samples have been taken representing the whole flow throughout twenty-four hours. These have been used in connection with records of the amount of water flowing in the river, furnished through the courtesy of Mr. J. H. Cook, Chief Engineer of the Society for the Promotion of Useful Manufactures.

From the data so secured the approximate amounts of the different polluting substances added by the city to the river have been computed, and the results have been compared with similar quantities contributed by other cities where similar data are available, and the data so secured indicate that the above estimate of additional difficulty from the presence of manufacturing wastes is sufficient.

The results have further been checked by analyses of samples of sewage taken from the various sewers in connection with gaugings of the quantities flowing in these sewers. These results are less complete owing to the large numbers of stations and the difficulty of adequately collecting samples and making gaugings. They indicate, however, a considerably smaller number of pounds of polluting material in the sewers than is shown by the river analyses. This is what might be expected as it is well known that much of the polluting matter enters the river in other ways than through the city sewers.

## STORM WATER.

Paterson has the combined system of sewerage. That is to say, the sewers serve to remove not only sewage and waste but also the storm flows and the natural runoff from the area served. The sewers at the present time serve an area of 2,752 acres, or 56 per cent. of the total area of the city which will ultimately require sewers. The sewers now built are so arranged that they can be extended as needed to serve 83 per cent. of the area of the city. For the other 17 per cent. entirely new sewers will be required. (2)

There is another system of building sewers, known as the separate system. With this system the sewers are used to remove sewage and wastes only. Another set of channels is provided to remove storm-water and the natural runoff. With this system the volume of sewage is smaller, and the sewage is less variable in amount and composition. The sewage can therefore be more cheaply removed or treated.

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(1) These are given in detail in Appendix I; page 3.

(2) For further details see Appendix VIII; page 99.

With the combined system every rain increases the volume of sewage, and a hard rain may increase it to 50 or 100 times the ordinary flow. There is no such increase with the separate system. Where sewage is purified or carried for long distances the separate system is to be preferred, and is, in fact often necessary.

Paterson and the greater part of Newark are sewered on the combined system. Substantially all the rest of the Passaic Valley is sewered upon the separate system.

Where the combined system of sewers is used it is customary to build intercepting sewers, and such pumps and other structures as are required, of sufficient capacity to take care of a volume of sewage equal to two or three times the dry-weather flow. This serves to keep all of the dry-weather sewage from the river, but in rains the flows are increased beyond the capacities so provided. When this happens only so much of the sewage is diverted from the river as is represented by the capacity of the intercepting works, and the balance is allowed to go through suitable outlets (usually the old ones) to the river.

Storm-waters wash the streets and flush deposits from the sewers, and the storm flow is often as dirty, or dirtier, than the ordinary dry-water sewage, but it differs considerably in character.

In winter not much harm is done by storm overflows because the same storms that produce them also serve to produce an increased flow of water in the river to dilute the filth so discharged. In summer the conditions are often different. A local thunderstorm may produce a large amount of very dirty overflow, without producing a corresponding increase in the flow of the river; and in this way very great pollution from storm overflows may take place with the combined system.

Taking into account Paterson's position I am confident that the separate system will have to be used ultimately, but I do not regard it necessary that the sewers should be immediately reconstructed. Care should be taken, however, that all those constructed in future should be designed for the ultimate use of the separate system.

To this end all sewers built in districts not now sewered should be upon the separate system, and all additions to sewers now built should conform to a general plan to be adopted now for the ultimate separation of the sewer from the storm water.

**Present Condition of Sewers.**

The records of sewers in the City Engineer's office are very incomplete and unsatisfactory. This is due to the loss of records in the fire some years ago; and the lost records have not been replaced. A general plan of the sewerage system has been made by the city engineer, and in making this a printed report, with a statement of the sizes of the sewers in various streets, which escaped the fire, has been of use; but the map so prepared, although the best available, is clearly not very accurate. There are no records of the elevations of the sewers, no profiles, no records of the slopes, carrying capacities, of areas drained now, or of the areas intended to be drained by the different sewers.

In order to get some information as to these matters I have examined by surveys the outlets from many of the city sewers; have taken the elevations to the inverts in a number of manholes above the outlets to determine the slopes; have measured the sizes and computed the carrying capacities, and have marked off upon a map of the city, furnished by the City Engineer, the areas now served and the areas to be ultimately served by each sewer, as far as possible. (1) In doing this I have had the assistance and co-operation of the City Engineer, but it has been necessary to get practically all of the information by study and observation, and not from the records. A table of the more important results is appended hereto. (2).

As a result of this study I find that most of the sewers are sufficient to carry away the storm water which may be expected. A few of them are much larger than is necessary for this purpose, and some are too small. (3).

The sewers of Paterson, it seems, are not regularly cleaned or inspected. In fact, some of them cannot be easily inspected, for the manhole covers have been built over in improving or paving the streets, and the sewers are now practically inaccessible.

The slopes of the sewers are very irregular. It frequently happens that there is a steep slope followed by a flatter one. (4). When this happens the velocity of the flow is checked by the flatter slope and there is a tendency to deposit sand and gravel from the street washings. Many of the sewer outlets also are submerged by high water in the Passaic river, and some even by ordinary water. This forms slack water near the outlets in which gravel deposits

(1) This map accompanies this report as Map No. 6 & 6a.

(2) Appendix VIII; page 99.

(3) Appendix VIII; page 99, contains a tabular statement.

(4) These profiles are shown on Map No. 7.

are formed. Investigation shows that many of the sewers are filled to a considerable depth with such deposits, and the carrying capacities are reduced materially below the capacities given in the table, which are computed on the supposition that the sewers are reasonably clean.

Carrying out any system of sewage purification or removal involves ultimately the reconstruction of the sewers to the separate system, but this need not be done all at once. The construction of an intercepting sewer to carry off the dry-weather flow will greatly improve the condition of the Passaic river, and some of the storm water may be allowed to enter the river for the present.

The sewerage system is being developed and is bound to be developed as long as the city grows. To make sure that it is developing toward the best ultimate condition the following should be done immediately:

A complete and accurate survey of all the sewers now in use should be made, showing the position of each manhole, and the elevation of the invert of each sewer at each manhole; the exact size of each sewer, the direction in which it flows, the elevation of the street surfaces, and in a general way the topography of the whole surface of the city.

When this map is made, a complete plan for the sewerage system of the city should be made by an engineer familar with sewer construction, using the sewers now in place as far as possible, but so designed as to give a complete system when the work is all carried out; and thereafter all sewers built should be built upon the lines of that plan. That is the only way in which good and economical results can be secured in the development of the sewerage system; and such results positively cannot be obtained with the present lack of imformation as to existing sewers, and lack of general plan as to extensions.

**Cost of Separating Storm Water.**

At the present time there are over seventy miles of sewers. Some of these are inadequate to remove the storm water and require immediate relief. In these cases it would probably be best to use the present sewers for sewage only, and to build new and larger drains to remove the storm water. Those of the present sewers which are large enough to carry off the storm water can, perhaps, in most cases, be ultimately used for that purpose, the sewage being carried in new, parallel and much smaller sewers. All new sewers should be built on the separate system.

The natural drainage conditions of Paterson are favorable.

The slopes are good, and the crookedness of the river is such that a very large part of the city is within a comparatively short distance of it. Long and expensive sewers, therefore, are unnecessary. With the steep slopes, catch basins need not always be very near together; gutters may be relied upon in cross streets where the distances are not too great; and in many streets it will be unnecessary to build storm-sewers. Judging from general experience the entire reconstruction of the sewers in the territory now drained will involve the construction of sewers or drains of an aggregate length of less than half of the present sewer length, or about 35 miles.

If these should all be built at once it would be necessary to take up and replace a great deal of expensive paving, but with a comprehensive system adopted it will be possible to change the sewers in installments and to do the work occasionally when repaving is being done, without added expense because of it.

On an average $3 per foot should serve to build these sewers and drains and their necessary connections and catch-basins, and this for thirty-five miles would amount to $550,000. This of course does not include the cost of sewers for additional areas. Sewers for such areas will not be more costly because the separate system is used.

The work of separating the storm water may be done gradually through a period of twenty-five to thirty years; and, done in this way, an annual appropriation equal to ten cents per capita will suffice, and I take this as the cost of installing the separate system in Paterson. The first year's appropriation should be used for the survey and plan above described. In following years the work should be done as streets are repaved, and in general where the greatest return for the money can be secured.

The policy to be adopted in regard to extending sewers and changing them from the combined to the separate system would not be affected in any way by the decision to use local purification to enter the trunk sewer. The storm water overflow is precisely the same in either case. It is the effect of this overflow upon the river which controls. The reason for removing it and the method of doing it are exactly the same in either case.

This matter therefore affects in precisely the same way any scheme of purifying the river which may be adopted, and need not be considered in comparing the relative merits of different propositions, but the cost of doing it must be included in any case, when the financial question is considered.

## AMOUNT OF DILUTION FURNISHED BY THE PASSAIC RIVER.

At the present time a part of the water which would naturally flow in the Passaic river is diverted for water supply purposes. Without attempting a close computation it may be stated that the minimum flow of the river at the present time is about 45 per cent. less than the full natural flow. (1) The ordinary flow is reduced by a much smaller percentage. This reduction in natural flow of the river is a substantial element in reducing the dilution of the sewage and increasing the nuisance resulting from it.

It has been thought by some that these diversions of water were chiefly responsible for the present objectionable condition of the river, but this is not so. While the natural flow of the river has been considerably decreased, the quantity of polluting matter emptied into it has increased much more rapidly, and if the full natural flow of the river were now restored, it would not suffice to remove the present objectionable conditions.

It has been suggested that the minimum flow of the river might be greatly increased by the construction of storage reservoirs upon the upper river, or its tributaries. (2) It is feasible to increase the flow of the river in this way, and many advantages would come from it. It would be possible to increase the minimum flow of the river to 50 per cent. more than its natural minimum flow, or perhaps to a greater extent. Such an increase in the flow of the river would not suffice, even at the present time, to purify the river and make it unobjectionable; much less would it suffice to adequately dilute the increasing volume of sewage which must be anticipated in the future.

Building storage reservoirs to increase the flow of the river, therefore, will not in itself serve to clean the river.

It might be made to help substantially, and if the flow of the river was increased as indicated it would be possible to use a less complete method of purification than would otherwise be necessary, and the separation of storm-water might be made more slowly, or even postponed entirely for some years, and this would result in some saving in the cost of works. This would be the case to an almost equal extent under the trunk sewer project. With either project minor manufacturing pollutions would be of less importance; and in general the river could be kept in good condition

(1) The figures from which this and the following computations were made are in Appendix XIII; page 123.

(2) Report of the Passaic Flood Commission, 1904.

with less effort and expense than would be necessary to secure corresponding results with a smaller flow.

This increase in the flow of the river by storage reservoirs is therefore desirable, and is almost equally desirable whatever system of purifying the river is adopted. It would not be adequate in itself, but it would be a substantial help.

## WORKS FOR PURIFYING PATERSON'S SEWAGE.

A large number of methods for purifying sewage have been proposed in the past, and there is a great variety in the works in actual use in different cities. At first thought it would seem to be a difficult matter to weigh the merits of the different systems of purification and to decide which to use. But in the last years there has been a very great advance in the art of sewage purification, and this advance has simplified the problem. This has come about through carefully conducted experiments in Massachusetts, in England, in Germany, at Columbus, Ohio, and other places, and by wide experience in purifying sewage on a large scale; and the result of this experience has been to show the impracticability of a great many methods formerly proposed and advocated, and to simplify the remaining methods, and on the whole to unify them; and at the present time there is far less divergence between methods of sewage treatment than was the case five or ten years ago.

The problem is now narrowed down until only a few different methods need be considered, and even among these, several are so closely allied that they really form but different parts of one general method.

### Methods of Purification Considered.

In the first place intermittent filtration or irrigation, or anything like a land treatment of the Paterson sewage is impossible. The necessary land for such treatment does not exist within practicable limits of distance. These processes might be considered in another location, for they are most useful where conditions permit; but for Paterson they are out of the question, and they will not therefore be further considered in this report.

The general method of treatment best adapted to your conditions is clearly indicated by European experience as found by Mr. Hewat, a member of your Committee, and my patner, Mr. Whipple, who visited Europeon plants to study them; (1) and also by the report of Mr. Clark, Chemist of the Massachusetts State Board of

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(1) Appendix II, page 35.

Health, who has had a wide experience in such matters and whose opinion I obtained upon this question. (1)

The type of works thus indicated is that which, with variations has been adopted in most of the newer and mere important sewage purification works in England and in this country, including the plant now under contract at Columbus, Ohio, and the plan just adopted for Baltimore. A general description of this method, and of the works required to carry it out for Paterson, is as follows :

**Intercepting Sewer.** An intercepting sewer is to be built following the river from Prospect street to Market street, a distance of 5.6 miles, increasing in diameter from forty-eight to seventy-eight inches as the tributary area becomes greater. A branch drains the north side of the river. (2) This intercepting sewer corresponds exactly to the first part of the trunk sewer, and the same plan and estimates are used ; and in general the plan followed by Mr. Hering and surveyed by him for the Passaic Valley District Sewerage Commission, with only minor modifications suggested by the changed conditions, is used.

This intercepting sewer will serve to take all of the dry-weather flow to a small sewage reservoir at the foot of Market street. The Market street sewer will be connected with the same sewage reservoir. The storm flows in excess of the capacity of the works will be allowed to flow through the old outlets to the river until such time as the separate system is installed.

**Pumping Station.** At the foot of Market street a pumping station will be built. The sewage will be screened as it leaves the reservoir and it will then pass through centrifugal pumps. The pumps to be first installed should have a capacity equal to about half that of the sewers, and for the present a part of the flow from storms in excess of the capacity of the pumps will be allowed to discharge to the river through the present Market street outlet.

The coarse material screened from the sewage will be burnt under the boilers. The sludge that accumulates in the sewage reservoir, which will act as a grit-chamber, will be applied to land.

**Purification Works.** From the pumping station a steel pipe laid across the river will extend for about 6,000 feet to a point near a branch of the Erie railroad, on a low knoll just above an extensive swamp. (1) Here the sewage will enter settling tanks holding half a day's flow. These tanks will be built to allow the deposits of sludge to be removed from them frequently and cheaply, and so that any tank can be cut out and cleaned while the others are in service. These tanks may be used as septic tanks, in which case the sludge will be removed only at long intervals; or they may be used as plain settling tanks, in which case the sludge will be removed frequently to avoid septic action; or chemical precipitation may be carried out in them, in which case apparatus for applying the chemicals to the sewage before it reaches the tanks must be added.

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(1) Appendix III ; page 77.

(2) The general location of this sewer is shown on Map No. 6, and of the whole project on Map No. 5.

The construction and size of the tanks for the three different system are substantially the same, and it makes but little difference for purposes of construction and estimate under which name they go.

The sludge removed from these tanks is to be taken to a second series of tanks, called sludge tanks, and it is proposed to make these tanks of considerable size. If the main tanks are used chiefly as settling tanks, as now seems advisable, the sludge tanks are to be of such size that sludge can be held in them on an average for a month, and with this done, it is expected that the sludge will undergo the septic process in them.

The septic process has the advantage over plain settling that it reduces the volume of sludge and makes it easier to handle and less offensive. It has the disadvantage, with reference to the effluent, that it greately increases the odor from it, and especially the odor from the filters to which the effluent is applied. It would seem that using the tanks as settling tanks only, thereby avoiding the strong odor of the septic effluent, and putting the sludge from them through the septic process afterward in separate sludge tanks, would combine substantially the advantages of the two systems.

This idea is represented to some extent in a number of recent English plants, although it has not been carried far enough yet to show just what practical results can be obtained in reducing the volume of sludge by septic action when separated from the sewage.

During the winter the septic action in the sludge tanks will not be strong, while the application of sludge to land frozen and covered with snow may prove unsatisfactory. Consequently, in cold weather it may be found advisable to use the settling tanks for septic sedimentation. The larger volume of sewage during the winter, and the lower temperature, would tend to prevent odors in the effluent.

(1) This arrangement is shown by Map No. 4.

**Filters.** The effluent from the settling tanks, freed from some of the floating grease and the greater part of the suspended matter, will be taken to sprinkling filters. These filters are to be constructed in the present swamp. They are to have concrete bottoms, with very open drainage systems. The filtering material is to be ten feet deep, of trap rock, crushed to go through a screen of two and one-half inch mesh, and be held on a screen with a clear mesh of about one inch, and washed substantially free from dust and fine matter. The settled sewage is to be applied to the top of these filters by numerous nozzles arranged to spray it over the whole area of the filters.

Filters of this type are extensively and successfully used in England at the present time, and are now under construction at Columbus, Ohio.

These filters bring the sewage in contact with air and allow rapid oxidation of the organic matters. No straining is desired. All the suspended matter in the applied tank-effluent goes through the filter, and in addition some of the dissolved matter is precipitated in the course of oxidation. It is essential to continuous satisfactory operation that there should be no permanent accumulation of insoluble matter in the filters, for such accumulation would finally choke the filtering material and prevent purification. The filtering material must, therefore, be so coarse that it will not act as a strainer, and the underdrains must be open and so arranged that they can be flushed, and all suspended matter must be constantly washed out, leaving no accumulation behind.

**Final Settling** The effluent from these filters is a turbid, unsightly liquid, but with much of the nitrogen converted into nitrates, and the putrescible organic matters destroyed. The liquid is taken to final settling tanks holding two or three hours' flow, in which the bulk of the suspended matters is deposited. The resulting effluent is fairly clear and is free from the putrescible organic matters which so pollute rivers as to make them offensive.

**Other Arrangements** Arrangements must be provided for flushing and cleaning all parts of the plant, and for collecting the dirty waters resulting therefrom and for taking them back to settling tanks, so as to collect ultimately all of the suspended matters in the sludge receptacles.

A certain amount of clogging of the filters will be inevitable, and after periods of ten or fifteen years the material in the beds will have to be removed and washed.

The sludge can apparently be best disposed of by putting it on and digging it into land. This will clearly be the case if the separated sludge goes through the septic action in the sludge tanks. Going through the septic process has the effect of largely deodorizing the sludge and reducing it in volume, and altering it to such a condition that it can be applied to land without making a local nuisance, and this is one of the chief objects of the septic process.

It does not seem likely that the dye stuffs in the sewage will be present in such quantity, as to seriously discolor the effluent. The processes of purification above described have only a limited power of removing these dye stuffs. If they should prove objectionable it would be necessary to apply chemical precipitation. This would make no considerable change in the construction of the plant, but would add materially to the cost of operation.

If a complete chemical precipitation process should be used the sludge to be disposed of would be greatly increased in volume, and it would be incapable of going through the septic action. Probably in this case it would be best to install sludge presses and press such sludge at considerable expense before applying it to land.

It may be best ultimately to provide for disposal of sludge by carrying it to sea, but this seems unnecessary at the present time.

The effluent from the final settling tanks is to be discharged into the Passaic river through a conduit built for that purpose, entering the river a short distance below Dundee Dam.

The location, general form and arrangement of works are shown by plans which I hand you herewith. (1)

**Land Required.** To adequately provide for the works about 500 acres of land should be secured. This land for the most part at the present time is a worthless swamp, but some higher and more valuable land is included. The land along the river road is not included in the 500 acres, but if it could be bought reasonably it would be well to control it. Toward the upper road, (that is, the continuation of Market street) there is some higher land which is now good farming land and is used for truck gardening. There are only four houses now upon the entire area, and they are not very valuable. (2)

On the whole, the 500 acres which it is proposed to secure are about as useless for building purposes as could be found, and the use of this area for sewage disposal will not interfere with anything of importance beyond the truck farming now conducted on that part of it which is dry enough for that use.

(1) Plan Sheet Nos. 4 and 5.

(2) All houses on or near the area are shown on Maps Nos. 3 and 4.

Some of the land is timbered, and the timber should be preserved as far as possible.

This area will serve for a very great extension of the works in the future as may be necessary. In fact, it is much greater than is required for actual use.

It would not be wise to locate purification works in this neighborhood without controlling a large area about them, because experience indicates that odors from such works are likely to be noticed for a distance of a quarter of a mile, and expensive and troublesome litigation can be avoided by owning all the property within a considerable distance.

The construction of the works can be made to serve incidentally for the drainage of the swamp, and this will increase its value; and all the land bought not immediately needed can be planted with trees or leased for truck farming, with the use of sewage sludge for fertilizer as desired.

In case the population in the general neighborhood increases in the future, so that the works become undesirable and are abandoned because of it, there is little likelihood of the city losing money on its investment in the land for the site, because an increased population which would render the works objectionable would certainly be accompanied by an increase in the value of real estate, which would compensate for the abandonment of any money invested in the works at that time.

The 500 acres which it is proposed to use for this purpose is not the only land which could be used. There is other land of more or less similar character adjoining, and in case exceptional difficulty is encountered in getting any part of it, some change in location might be made, but in a general way this site is the only one available within a reasonable distance of Paterson, and is the only one which has been considered.

The legal question of building works in another county was considered, and Edmund G. Stalter, City Counsel, has given his opinion that the city has the right to do this. (1)

**Amount of Sewage Per Capita.**

For the purpose of this estimate I assume that the dry-weather flow of sewage is 100 gallons daily per capita, and that the average flow is 125 gallons, and that the maxium rate of flow to be taken care of is double this quantity, or 250 gallons daily per capita. These figures are based upon a study of the amount of public water supply, and the amount of ground water, and amounts of manufacturing waste. (1)

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(1) Appendix XI; page 117.

The same figures are used in estimates for the trunk sewer for the whole of the Passaic Valley district. Paterson probably has more manufacturing waste per capita than the whole district. On the other hand, owing to the compactness of the population, and the large amount of ground water drawn from the ground by wells for manufacturing purposes, the amount of ground water entering the sewers per capita is less, and this probably fully balances in volume any excess of manufacturing waste.

In this connection it may be will to state that the Metropolitan sewers for Boston fifteen years ago were designed to have capacities ranging from 225 to 262, and averaging 238, gallons per capita, and experience has shown that these estimates were not too large. In making estimates for additional sewers in the same system at the present time, Mr. Wm. M. Brown, Chief Engineer, uses basing capacities of from 251 to 300 gallons per capita daily. (2)

It is true that in Europe the quantities of sewage discharged are very much less than in this country ; and there is a tendency to reduce the consumption of water here ; and if a radical change takes place in this respect, the volume of sewage will be to a considerable extent reduced, and the life of the structures now built will be correspondingly increased. This is a possibility, but not a certainty, nor even a probability at the present time.

**Cost of Construction.**

I have prepared an estimate of the cost of the necessary works to treat the sewage and wastes from a population of 250,000, in this way. This population is selected because it allows the same ratio of growth for Paterson alone that the capacity of the trunk sewer, as proposed, allows for the growth of the whole district, as will be shown in a subsequent paragraph, and it seems best to make the two estimates strictly on the same basis.

It does not follow that this would be the best size to use in designing such works in case they were to be built. As a matter of fact, on the plan showing the general arrangement of works, which accompanies this report, the works are shown much larger than are covered by this estimate. On the other hand, for the present it would suffice to build parts of the works 40 per cent. smaller than the sizes covered by the estimate.

(1) Appendix X ; page 111.

(2) Metropolitan Sewerage and Water Board ; Fourth Annual Report, 1905, page 175.

A schedule of the estimate is as follows :

### ESTIMATED COST OF INTERCEPTING SEWERS, PUMPING STATION AND PURIFICATION WORKS, COMPLETE, FOR TREATMENT OF PATERSON'S SEWAGE ALONE, THE WORKS BEING PRECISELY AS LARGE IN PROPORTION TO THE PRESENT POPULATION AS THE PROPOSED TRUNK SEWER IS IN PROPORTION TO THAT OF THE WHOLE DISTRICT. (1).

| | |
|---|---|
| Population of Paterson in 1905 | 111,529 |
| Population to be provided for, 2.25 of that of 1905 | 250,000 |

50 per cent. added to sizes of tanks and filters for manufacturing wastes.

| | Total estimate | Amount not required at first. |
|---|---|---|
| Branch sewers north of river in Paterson, sizes, 24 inches to 36 inches complete | $ 40,000 | |
| Intercepting sewer, 5.6 miles, from Prospect street to Market street, sizes 4 feet to 6.5 feet; masonry and excavation | 564,900 | |
| Replacing paving, supporting street car lines, railroads, buildings, stream-crossings, right of way, etc. | 120,000 | |
| Total cost of intercepting sewer to foot of Market street | $724,900 | |
| Pumping station at the foot of Market street including receiving tank, overflow and appurtenances, 5 pumping units, each 14 million gallons capacity, (capacity 260 gallons per capita.) | 255,000 | $ 51,000 |
| 60-inch rising main to purification works, 6,300 feet, including river crossing | 103,000 | |
| Settling or septic tanks, holding 20 million gallons, (80 gallons per capita) | 200,000 | 80,000 |
| Sprinkling filters, 10 feet deep, with a net area of 20 acres (0.08 acre per thousand) | 1,000,000 | 400,000 |

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(1) Some of the items are shown in greater detail in Appendix VII: page 95.

| | | |
|---|---|---|
| Final effluent settling tanks, holding 5 million gallons, (20 gallons per capita) | 50,000 | 20,000 |
| Sludge tanks, holding one month's supply of sludge, 10,000 cubic yards capacity, with appliances for economical emptying, (40 cubic yards per thousand) | 80,000 | 32,000 |
| Carried forward | $2,412,900 | $583,000 |

| | Total estimate | Amount not required at first. |
|---|---|---|
| Brought forward | $2,412,900 | $583,000 |
| Power-house and equipment for handling sludge, pumping back flushing waters, etc. | 50,000 | 20,000 |
| 72 inches outlet from purification works to Passaic river, about 4,500 feet | 90,000 | |
| Land, right of way, draining, roads, etc. | 200,000 | |
| | $2,752,900 | $603,000 |
| Engineering and contingencies, 10 per cent. | 275,290 | 60,300 |
| Total cost of purification works | $3,028,190 | $663,300 |
| Of the above works an approximate expenditure of twenty per cent. of the total could be postponed for the present, amounting to | 600,000 | |
| And the cost of works to be built at once would be | $2,428,190 | |

**Cost of Operation.** I shall take this and all subsequent estimates on a per capita basis, as this will facilitate comparisons. The populations to be served at different dates are speculative, and the costs will be in general more nearly proportional to the population than to other matters.

The cost of taking care of the sewers, inspecting them, keeping them clean, of looking after connections and overflows, and of pumping the sewage, I estimate at eighteen cents per capita annually.

It is particularly difficult to estimate accurately the cost of operating the sewage purification works; first because the processes on which the estimates are based are new, and extended experience on a large scale has not yet been had with them; second, because such data as have been obtained are mostly from England, where conditions as to volume of sewage, strength of sewage, and wages paid, are very different from those in this country; and third, because Paterson sewage contains, or will contain when the dye-houses are connected, a larger amount of manufacturing waste than usual, and the cost of treating it will therefore be greater than that of treating the sewage of an average city, and the addition to be made for this condition is difficult to estimate with certainty. The costs of operation deduced from English experience therefore are only applicable after many corrections, and the methods of correction are matters of judgment and necessarily only approximate.

I have been through the data collected in England by Mr. Hewat and Mr. Whipple, and have applied corrections which in my judgment seem reasonable. I have studied the reports available, containing statements of cost; I have taken into account the actual costs of operation of sewage purification works in this country, for, although these works differ considerably from those proposed under this estimate, they do in a measure serve as a guide to the expenses to be expected in purifying sewage on a large scale.

I have also made various calculations as to the probable amount of sludge to be produced, the cost of handling it per cubic yard, the cost of operating sprinkling filters, and of washing the filtering material after a time, and of the cost of superintendence. After a study of these matters I estimate that the operating expenses of the proposed plant, as nearly as can be determined, will be thirty cents per capita annually.

I am aware that in some cases much lower estimates of cost of operation of similar plants have been made; but in these cases the problem has not been complicated by manufacturing wastes, and the estimates further seem to rest upon the assumption that all parts of the plant and of the labor-saving devices will work as intended, and they do not rest upon actual experience with corresponding equipment. Calculations made in this way, it is well known, are likely to fall short by reason of contingencies not taken into account in making up the schedules; and I therefore believe that it would not be prudent to use a figure lower than the one above mentioned.

For comparison, the cost of operating the sewage precipitation works at Providence is about twenty-five cents per capita annually, with a far less complete purification than is necessary at Paterson; and at Worcester the cost is over forty cents per capita annually, also with less complete purification of effluent, although there are indications that, with a modern plant, better results could be secured at Worcester at no greater, and very likely less, cost. Worcester has a great deal of manufacturing waste to deal with, although this waste is different in character from that requiring treatment at Paterson.

In England, with labor a third cheaper, and with only a third of the quantity of sewage per capita to deal with, the average cost of maintaining works seems to be about fifteen to seventeen cents per capita annually.

The separation of storm-water at Paterson will require a further expenditure of ten cents per capita, as I have already mentioned.

This brings the total operating expenses of the plant, including the care of storm-water, to fifty-eight cents per capita annually.

**Total Cost of Purification.** To this must be added the interest and sinking fund charges on the capital invested. These may be reasonably taken together at five per cent.

The per capita cost of the works when the population is fully up to the capacity of the works will be $12, but during the years before this condition is reached it will be greater. At the outset, the cost of works, based upon the population of 1905, will be $21.50. Based on the estimated population of 1910 the works to be constructed at first will cost $18.60 per capita. Taking it right through a series of years I compute that the average investment in works per capita will be $16. This represents an average use of the whole plant to 75 per cent. of its full capacity, and experience shows that this is about as high a coefficient of use as can be reasonably expected with such undertakings.

Five per cent. of $16 is 80 cents per capita annually for capital charges. Adding this to the operating expenses, the total cost to the city of Paterson for construction and operation of works for local purification will be $1.38 per capita annually. Actually the cost will be somewhat greater in the early years and somewhat less after a time, when the population has increased more nearly to the full amount provided for.

All these figures of course are based upon present conditions and prices, and the present state of development of the art of sewage purification.

## TRUNK SEWER PROJECT.

The trunk sewer project for cleaning the Passaic Valley was proposed by the Passaic Valley Sewerage Commission in 1897, of which Mr. Chas. E. A. Jacobsen was Chief Engineer, and Mr. A. Fteley was Consulting Engineer. At that time it was proposed to discharge the sewage into Newark Bay (1) and ultimately, when it became necessary after a generation or more, to take it across Staten Island into Lower New York bay.

**Discharge into New York Bay.** In 1902, after further consideration and acting upon the advice of Messrs. Rudolph Hering, J. James R. Croes and William M. Brown, Counsulting Engineers, the State Sewerage Commission recommended a project following the main lines in the earlier one, but differing in important particulars.

The most important difference was in the point of discharge. This was changed to a point near the middle of the Upper Bay about half a mile north of Robbins Reef Light.

In 1903 the Passaic Valley District Sewerage Commission, of which Mr. Rudolph Hering was Chief Engineer, made a further report in which substantially the same project was adopted, although charges were made in the alignment and other details, and the capacity of the sewers was somewhat increased over those previously recommended. Later the same Commission made a supplementary report on the proposed outlet, with professional opinions favorable to it by a number of eminent engineers ; namely,

General Henry M. Robert, U. S. A.
George S. Greene, Jr., C. E.
Edlow W. Harrison, Consulting Engineer.
Allen N. Spooner, C. E.
Lieut.- Colonel C. W. Raymond, U. S. A.

Mr. O. H. Tittman, Superintendent U. S. Coast & Geodetic Survey, also gave a statement as to volumes of flood and ebb tides.

All the above mentioned reports are printed documents. For the purposes of this study I have adopted Mr. Hering's plan as being the best plan for a trunk sewer thus far proposed.

**Mr. Hering's Plan.** My information as to Mr. Hering's project is derived from the printed report which contains a statement of the aggregate estimate of cost, but without details, and shows the route and profile of the main sewer and the general routes of some of the tributaries.

(1) The proposed outlet and those of the following project are shown on Map No. 2.

Through the kindness of the Passaic Valley District Sewerage Commission I was permitted to examine, and afterwards to obtain blue print copies of lands showing the location and profile of the proposed main sewer. I was also furnished with a table of lengths and some dimensions of tributary sewers, and with a statement of the carrying capacities of these sewers and of the main sewer.

I was unable to secure any other information concerning this project, and I have been unable to find of what materials it was proposed to build the sewers, or what their shapes were to be, or what methods of construction were intended, or how the estimate of cost was reached. As no information upon these points has been obtainable I have made estimates for the construction of a system following the lines shown by Mr. Hering's plans, but with such construction and materials as I have thought suitable.

**Size and Capacity of Proposed Trunk Sewer.**

The sewer as shown by Mr. Hering's plan seems reasonably sufficient, as I compute it, for the needs of the district until the population reaches about 1,290,000 people, to be anticipated in 1932, although the estimate of cost only includes pumps, outlets, and certain other appurtenances suitable for half the ultimate capacity; that is, for the needs of a population of 645,000, to be expected in 1909, and considerable additional expense will be required at an early date, or even at the outset, to increase these capacities to meet the requirements of the district.

The plan submitted is only of a very general character and therefore does not admit of examination in detail; and while some modifications and additions, even to the general outline, may be desirable, it is in the main sufficient to serve as a basis of a reasonable estimate of cost.

It is only fair to say that Mr. Hering states that this was as far as his plan was intended to go. He did not intend to show details or to limit the project to any particular types of construction.

**Capacity of Different Portions of the Sewer.**

In examining the computed capacities of the different parts of the trunk sewer in comparison with the tributary areas, the excess capacity at the upper end is a most striking feature. The capacity from the Paterson end is very much greater in proportion than the lower end of the line, as is shown by the following tabular statement. (1)

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(1) These areas are indicated on Map No. 1. On that some of the areas are further sub-divided.

| | At Paterson city line. | Just below third river. | Just below second river. | At pumping station. | Total |
|---|---|---|---|---|---|
| Capacity of proposed trunk sewer million gallons daily | 77 | 162 | 235 | 324 | 324 |
| Increase, being carrying capacity for each section | 77 | 85 | 73 | 89 | 324 |
| Tributary, area square miles | 8 | 29 | 20 | 25 | 82 |
| Population, 1905 | 112,000 | 61,000 | 99,000 | 300,000 | 572,000 |
| Number of people per acre | 22 | 3 | 8 | 19 | 11 |
| Sewer capacity per square mile, million gallons | 9.6 | 2.9 | 3.6 | 3.6 | 4.0 |
| Sewer capacity, per inhabitant, gallons | 690 | 1,390 | 740 | 297 | 567 |
| Sewers provide 250 gallons per capita for a population greater than the present by the ratio of 1 to | 2.75 | 5.55 | 2.96 | 1.19 | 2.26 |

It appears probable that the excess capacity at the upper end was provided with reference to the supposed volumes of manufacturing wastes. As noted elsewhere in this report, so far as Paterson is concerned, this allowance is in large part unnecessary; and the size of the upper part of the sewer might be considerably reduced. I think it better to retain this excess capacity, however, so that the sewer will be large enough to serve the area above and near Paterson, which at no remote period will require sewerage facilities. In view of the physical necessity of providing an outlet for this additional population, the extra capacity at the upper end is wise and should be retained, and the sewer as shown is very ample for any requirement of this kind for at least a generation, and perhaps for a longer period.

**High and Low Level Sewers.** The trunk sewer is proposed to drain the whole of the lower Passaic Valley, and all the sewage removed by it will require to be pumped before it is discharged. The greater part of this district is elevated, and sewage from it would flow to sea without pumping if suitable channels were provided.

The trunk sewer now proposed will serve the whole district for a certain period of years. It is unsafe to attempt to predict at this time how long this period will be. In the Metropolitan Sewage district of Boston in all cases the capacities of the trunk sewers have been reached, or will be reached, before the times that were expected when they were built, and the assumptions as to requirements were more liberal than those made by Mr. Hering in designing the trunk sewer. (1) It is, therefore, possible that the proposed trunk sewer will become inadequate for the needs of the district at an earlier date than has been estimated. Whenever this time comes it will be necessary to build an additional outlet. This will not be provided by a second sewer parallel with the one first built, but can best be secured by a sewer at a higher level; capable of taking the sewage from the higher and larger part of the district to the outlet by gravity. Such a sewer is clearly feasible.

I hand you a map showing, in a general way, that part of the Passaic Valley district which might readily be made tributary to such a high level sewer. (2).

A high level sewer would first remove the sewage in greatest measure from the district tributary to the lower or southern part of the trunk sewer, but could be extended to take also a large part of the sewage from the upper or northern part of the district.

After that is accomplished the trunk sewer first built will drain only the lower part of Newark and a narrow strip along the Passaic river, reaching up approximately as far as Passaic, and then broadening out to include a considerable area of ground not sufficiently elevated to be reached by the high-level sewer. (3)

It would seem not unreasonable to contemplate this ultimate condition and to design the trunk sewer with reference to it. In a general way apparently the present design adapts itself to this use by the large excess capacity at the upper end, but it would seem reasonable to revise the project somewhat to adjust it more closely to the contemplated conditions.

I have not taken this matter up in detail as it is clear that such re-adjustment of sizes and carrying capacities would not change to a material extent the cost of the whole project, and this is the only matter which I have attempted to investigate at this time.

**Point of Discharge.**

Mr. Hering, following the Hering-Croes-Brown project, recommends the discharge of sewage into New York harbor. From the standpoint of

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(1) Mr, Hering regarded the capacity of the trunk sewer as sufficient to serve 1,500,000 people. I have reduced this allowance to correspond with the estimated required capacity of 250 gallons per capita daily as elsewhere explained.

(2) Map No. 1.

(3) Shown on Plan Sheet No. 1.

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New Jersey this seems to be clearly the most advantageous point of discharge. Many people in New York have objected to such discharge, and the objection led to the appointment of a Commission on the pollution of New York bay, and of a formal report upon the subject in 1905, and quite recently to further action in the same direction.

It is questioned whether or not New York has the legal right to stop the discharge of sewage at the point and in the way proposed. Different opinions have been expressed upon this point, and it seems that this is a matter which can only be finally settled in the courts if the necessity for a settlement should arise.

It may also be questioned whether, in case the court should hold that she had the legal right to do it, New Jersey would wish to discharge the sewage in the way proposed, and whether it would be wise for her to do so, in spite of New York's protest.

It is clear, however, that in case New Jersey should abstain from using the harbor because of New York's objection to the additional pollution, either voluntarily or through constraint, it would only be fair for New York to make a corresponding effort to prevent sewage discharge on the New York side of the bay.

It must be admitted that New York is better off without the discharge of New Jersey sewage. The discharge of sewage will tend to pollute the bay locally. There will be an appearance of sewage for some distance around the proposed outlet, and this outlet is near the main channel up the harbor. There will be some odor, and grease from the sewage will smooth the waves and show its presence over a considerable area.

To a certain extent these phenomena are disagreeable and objectionable, and if New York could stop them without damage to others it is clearly for her interset to do so.

New York is now putting practically all of her own sewage into the harbor.

The New York Pollution Commission (1) lays great stress on the fact that this sewage is put in at a great many points separated from each other, and that no such large body of sewage is put in at one point as would be contributed by the Passaic Valley outlet. There may be a question as to how much weight should be given to this contention.

The main facts are that New York is disposing of substantially all of her sewage by dilution in the water of the harbor, and that the water of the harbor is not seriously polluted by this discharge at the present time.

The oyster industry perhaps suffers from it, but I believe that

(1) Report of New York Bay Pollution Commission, 1905, page 16.

growing oysters in the harbor should be prohibited forthwith, and that without reference to the proposed discharge of New Jessey sewage.

New York harbor is clearly capable of receiving the sewage of a population very much larger than that now tributary to it without becoming objectionably contaminated, but there is a limit to the amount which can be so discharged. If the city keeps on growing the limit will be some time reached. If the New Jersey sewage is kept out of the harbor, then the limit will not be reached as soon, and New York's sewage can be discharged for a longer interval without producing offensive conditions.

New York would rather have the New Jersey sewage kept out of the harbor. But it may be questioned whether she has the legal or moral right to refuse to share the natural advantages of the harbor with her neighbor, who owns a considerable proportion of its shores and would seem by right fully entitled to share in the advantages of the location.

**Outlet in Kill Von Kull.** A possible solution of this problem which deserves consideration is the use of an outlet in Kill Von Kull or in Newark Bay near the upper end of it. (1) Following the New York Bay Pollution Commission report, but with some revision, the total population tributary to New York harbor, including the Passaic Valley and all territory tributary to Newark Bay, in 1905, was 5,048,000. I compute that of this 778,000 were tributary to Newark Bay directly, or 15.4 per cent of the whole. I have included in this figure not only the whole of the Passaic sewerage district, but also the suburban part of the Hackensack valley, and Elizabeth, and the towns which might reasonably reach Newark Bay from that general direction.

The tidal volume (flood) flowing through Kill Von Kull, according to the same authority, is 1,750 million cubic feet, while the total tidal volume (flood) flowing through the Narrows is 12,750 million cubic feet. The tidal flow through Kill Von Kull therefore is 13.7 per cent. of the tidal flow through the Narrows, or substantially as much in proportion to the New Jersey sewage as the flow through the Narrows is in proportion to all the sewage.

The ability to absorb and dispose of sewage depends somewhat upon other matters than the tidal flow, but in a general way the tidal flow is a good index of absorbing power, and we shall not be

(1) Shown on Map No. 2.

far wrong in assuming that the Kill Von Kull is capable of disposing of as much sewage in proportion to its tidal flow as is New York harbor in proportion to the flow through the Narrows; and on this basis the opportunity for sewage discharge into Kill Von Kull for New Jersey is substantially as favorable as for the discharge of all the sewage of Greater New York into New York Bay, including Kill Von Kull.

In one respect Kill Von Kull is particularly favorable as a point of discharge. The tidal currents are very strong. The advantage of strong currents is obvious from an inspection of the outlets in Boston harbor, where the sewage is more rapidly and completely dispersed in the stronger currents. And this circumstance may offset the fact that the outlet to Kill Von Kull would be nearer inhabited shores than the outlet in New York Bay, north of Robbins Reef Light.

From a point in the proposed trunk sewer line in Newark where the lines might diverge, the distance to an outlet in Kill Von Kull is about 11 per cent. less than the distance to the proposed New York Bay outlet. The general form of construction in the two directions would be similar and it seems that there would be no very great difference in the cost of carrying the sewage one way or the other. If there is any difference, probably it would be cheaper to go to the Kill Von Kull outlet.

**Adequacy of the Kill Von Kull Outlet.**

It seems fair to count on the use of an outlet for the New Jersey sewage in the Kill Von Kull for at least a generation, and in all probability for a much longer time. This matter is speculative when we try to get far into the future. We do not know how rapidly the cities will grow or what standards of cleanliness and nuisance a future generation may have, nor do we know what the polluting power of the sewage of the future will be, for it is quite possible that, owing to changed habits, food and manufacturing conditions, it may be materially different from that of the present day. And further, our information as to the present ability of such tidal flows as those in Kill Von Kull to absorb sewage is of a very inadequate character and does not allow a close estimate of sewage absorbing ability even at the present time.

The length of time that such an outlet could be used, therefore, either in Kill Von Kull or New York harbor, is a matter which will be determined by experience as the years go by, and is incapable of being calculated at the present time. It is clear that either outlet is sufficient for the present and for a long series of years, and we may therefore base our estimates upon the use of one of them, and we may assume that the cost will be about the same whichever is used.

**Preparatory Treatment for Tidal Discharge.**

Whatever outlet for tidal discharge is adopted there are some things that can and should be done to improve the situation. The objectionable appearance of the sewage largely comes from two matters; first, from the floating oil and grease; and second, from the coarser suspended and floating matters. In some sewer outlets now in use these materials are separated in part, but it is clearly possible to carry the separation much further without undue expense. Tanks with scum boards should be provided to allow the sewage to come to rest, and be freed from as large an amount as possible of the floating oil and grease; and the screening should be done through closer screens with automatic cleaning devices so that no considerable floating particles will be observed in the discharged sewage. The prevention of the appearance of sewage will substantially reduce the objection to its discharge, although it will not materially change the condition as to odor and the general pollution of the Bay.

**Power of the Harbor to Absorb Sewage.**

In this connection it may be stated that there is no danger of over-taxing the oxidizing power of the Bay and Harbor water at the present time. The amount of sewage now discharged is so small as to use only a fraction of the absorbing power of the salt water, which is brought in with every flood tide. Approximate computations indicate that one-fourth of the water coming into the harbor at each flood tide is sea-water which has not been in the harbor before, and it is this new sea-water which principally gives the harbor its enormous power of absorbing sewage. The fresh water which enters the harbor through various rivers is a minor and almost unimportant element in the problem. At times of flood in these rivers the fresh water, to a large extent, takes the place of the salt water and drives the salt water out, and for the time being the fresh water takes the place of the salt water in absorbing sewage. But this is an unusual condition; if the fresh water did not enter at this time, the salt water would do so, and it is the salt water which is depended upon, and which does the bulk of the work, especially in dry weather when the river flows are low and when the sewage is most likely to be offensive.

The salt water is cooler than the fresh water, and for this reason has a greater power of absorbing and oxidizing and destroying the sewage with which it mixes, and the processes which give rise to offence are less likely to take place at a lower temperature than at the high temperatures which are reached in fresh water in midsummer.

**Cost of Trunk Sewer.** I estimate the cost of constructing the trunk sewer and branches complete, in general accordance with Mr. Hering's plan, but with such sections and details as seem proper to me, as follows:

ESTIMATE OF COST OF TRUNK SEWER, FOLLOWING IN GENERAL MR. HERING'S PLAN, WITH A CAPACITY OF 324 MILLION GALLONS PER DAY, SUITABLE TO TAKE SEWAGE AT A MAXIMUM RATE OF 250 GALLONS PER CAPITA FOR A POPULATION OF 1,290,000, WITH OUTLETS AND PUMPS FOR FULL CAPACITY. (1)

(The population provided for is 2.25 of the population of the proposed district in 1905, which, with a growth of three per cent. per annum, will be reached in 1932).

| | Total estimate. | Amount not required at first. |
|---|---|---|
| Branch sewers, north of river in Paterson, sizes 24 inches to 36 inches, complete | $ 40,000 | |
| Trunk sewer, 5.6 miles, from Prospect street to Market street, 4 feet to 6.5 feet, masonry and excavation | 564,900 | |
| Replacing paving, supporting street-car lines, railroads, buildings, right of way, etc. | 120,000 | |
| Total cost of trunk sewer to foot of Market street | 724,900 | |
| Main sewer, from foot of Market street to pumping station, 15.6 miles, 7 feet to 13 feet in diameter, masonry and excavation | 3,805,000 | |

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(1) Some of the items are given in greater detail in Appendix XX; page 149.

| | | |
|---|---|---|
| Replacing paving, supporting street-car lines, railroads, buildings, stream crossings, extra work in pumps, right of way, etc. | 1,202,000 | |
| 5,690 feet of sewer, 13.5 feet in diameter, in Jersey City and Bayonne | 349,000 | |
| Railroad crossings, swampy land, right of way, etc. | 84,000 | |
| 4 lines 6 foot cast iron pipe across Newark Bay, 8,680 feet each line, at $50 per foot | 1,736,900 | $868,000 |
| Carried forward | $7,900,900 | $868,000 |

| | Total estimate. | Amount not required at first. |
|---|---|---|
| Brought forward | $ 7,900,900 | $868,000 |
| 2 lines 8 foot cast iron pipe under New York bay, 13,330 feet, @ $88 per foot for each line | 2,344,000 | 1,172,000 |
| Lateral sewers, Wallingford Branch, Lindhurst branch, Harrison and Kearney branch; sizes 12 inch to 42 inch, about 11 miles | 407,000 | |
| Grease removing tank, holding fifteen million gallons, with appurtenances and machinery for close screening | 300,000 | |
| Pumping station, foundations and buildings, complete; suitable for lifting the whole quantity of sewage | 1,100,000 | 450,000 |
| Two small auxiliary pumping stations for laterals | 60,000 | |
| | $12,111,900 | $2,490,000 |
| Engineering and contingencies, 10 per cent. | 1,211,190 | 249,000 |
| Total estimated cost of trunk sewer | $13,323,090 | $2,739,000 |
| Of the above works approximately 20 per cent. may be postponed for the present | 2,700,000 | |
| Leaving the cost of works to be built at once | $10,623,000 | |

With the outlet in Newark bay near Kill von Kull instead of in New York bay, the cost of construction might be 5 per cent. less. Of the whole amount estimated, about 40 per cent. is for the outlet works.

**Excess Over Mr. Hering's Estimate**

This estimate brings the cost to about 22 per cent. more than Mr. Hering's estimate. A part of this increase is due to the addition of appliances for removing grease and for close screening of the sewage; a part is due to including an estimate of the cost of securing the right of way, which was not included by Mr. Hering; a part is due to the extra expense of maintaining and replacing the additional paving, steam and street railways which have been constructed and other developments on the line of the sewer since Mr. Hering's estimate; and the rest represents increase in cost of doing work in the interval, and greater estimates of cost on the various items, which I have made.

**Capacity of Proposed Sewer.**

The capacity of 324 million gallons per day is reached as follows: The actual slope of the last section of sewer is 0.38 foot per thousand. The hydraulic slope of the water in the sewer is less than this, and follows the top rather than the bottom. The slope of the top is less than the slope of the bottom as the sewer increases in size. The controlling slope of the sewer, at the top, is 0.35 foot per thousand, and at this slope a circular sewer 13 feet in diameter will carry 324 millions gallons per day. If the masonry is very smooth it would carry a little more than this amount, but for ordinary masonry construction fouled by sewage it is not safe to figure upon a larger discharge. This quantity represents a velocity of 4.43 feet in each of the four 6-foot pipes across Newark Bay, and of 5.00 feet per second in each of the two 8-foot outlet pipes in New York bay, and these velocities are as high as they can well be.

The use of 250 gallons per capita daily as the required capacity, instead of the lower one used by Mr. Hering, reduces the estimate of population which can be served by a given capacity, and therefore the length of the time for which relief will be afforded by this particular sewer.

It may be that it would be better to put more and smaller pipes under New York bay, and separate the outlets, as is planned for the Nut Island outlets at Boston, where two outlets are now in use and two others are contemplated. This change would not add greatly to the cost; it might even reduce it slightly.

**Cost of Operation.**

The cost on inspecting, cleaning and administering the sewerage system, and of pumping the sewage, I estimate at 18 cents per capita annually. This figure is the same as for the corresponding items for Paterson alone. Paterson alone would save something on the cost of general administration, but on the other hand, the cost of pumping in a small station would be somewhat more per million gallons than in the larger one serving the whole district.

To this figure I add five cents per capita annually for the cost of removing and disposing of the grease and suspended matter removed by the final tanks and screens which are contemplated, making a total estimated cost of operation of 23 cents per capita annually.

**Entire Cost Under Trunk Sewer Project.**

To Paterson's share of the general cost must be added the cost of gradually separating the storm-water, as previously stated, at 10 cents per capita, making in all 33 cents per capita to be raised by Paterson on account of the operating expenses under the trunk sewer plan.

The cost of the works to be now constructed amounts to $18.50 per capita of the 1905 population, or $16.20 of the estimated population of 1910. When the whole system is completed and serves a population of 1,290,000, the estimated capital invested will be $10.50 per capita.

During the period for which these works will serve, the capital invested per capita will fluctuate between these limits, and I compute will average $14 per capita, which (as in the case of the separate works for Paterson) represents an average use of the works to 75 per cent. of their full capacity.

**Paterson's Share Determined by Valuations.**

It is the understanding that Paterson's share of the cost is to be determined by the ratio of her valuation to the valuation of the district. Paterson's proportion of valuation is 11.5 per cent. less than her proportion of population, according to the valuation lists and census returns of 1905. (1) Upon this basis, the capital expenditure for which Paterson would be responsible would average through a period of years 88.5 per cent. of $14.00, or $12.40 per capita, and the capital charges upon this sum at five per cent. would amount to 62 cents per capita for the inhabitants of Paterson.

(1) Detailed figures of population and valuation for 1905 are contained in Appendix XVI; page 137.

Adding this to the operating expenses and the care of stormwater, as computed above, the total cost to Paterson of entering the trunk sewer project would be 95 cents per capita per annum through a series of years. This cost will be somewhat more in the earlier years, and somewhat less in the later ones.

**Comparative Cost of Other Trunk Sewers.** For comparison the cost of the general trunk sewer system in the valleys of the Rahway and Elizabeth rivers, described page 280, Engineering Record, Vol. 49, was $750,000, and served a population, when built, of nearly 40,000 people. The cost, therefore, was about $20 per capita.

For further comparison, in the Boston Metropolitan district in the year 1905 the population living in the territory tributary to the sewers was 779,500, and the assessments raised were $820,000, or $1.05 per capita. The works had cost $13,712,000, or $17.60 per capita, and the operating expenses were $263,593, or 34 cents per capita. The assessment represents thirty-four cents for operating expenses and sixty-one cents for capital charges, sufficient to pay 3.45 per cent. on the capital invested. This low rate on the capital, I believe, is due to deferred sinking fund payments, and to the very low rate of interest prevailing when large bond issues were made. On a 5 per cent. basis the assessment would need to be raised to $1.22 per capita. Only 69 per cent. of the population was actually connected with the sewers. This is apparently due to the very recent introduction of sewers in much of the territory where they were impossible before the Metropolitan outlets were built.

**Possibility That Sewage From the Trunk Sewer Will Require Treatment.** There is a possibility that some time objection to the discharge of crude sewage, either in New York Bay or Kill von Kull, will become so strong that it will be necessary to purify the sewage collected by the trunk sewer. There is no indication of an early necessity for this. But it is possible that such treatment will be required some time, and whenever that time comes, it will add materially to the cost of the trunk sewer project; and this feature of the case should be taken into account by Paterson in deciding which system to adopt.

If the sewage collected in the trunk sewer was as difficult to treat, and the treatment was as thorough as has been estimated for in the case of Paterson alone, then the installation of such works would represent an average additional capital investment of about

$8 per capita, and an increase in the cost of the whole project, including capital charges, of about 70 cents per capita annually. This figure may be reduced, however, by the five cents per capita for the removal of grease and screening in the trunk sewer estimate, leaving a net increase of sixty-five cents.

It may further be fairly assumed that, owing to the more favorable point of discharge of effluent, a less thorough purification would suffice, and also that there would be less manufacturing waste in the sewage of the whole district, and therefore that it would cost less to purify it in proportion than to purify the sewage of Paterson alone. On the other hand, it does not appear that as favorable a site for works exists, and the cost of construction might be very considerably increased in proportion.

It was suggested some years ago that the sewage from the trunk sewer be purified by works located on the meadows below Newark and then discharged into Newark Bay. (1) This plan was adversely reported upon at the time, but in case legal and other objections should prevent crude tide-water discharge, it is not impossible that it may be taken up again.

Since this plan was first proposed there has been a considerable development of railroad and manufacturing properties in this general neighborhood, and the question of site for works would have to be again determined with reference to the present conditions.

Foundation for sewage purification works upon the Newark meadows would be very expensive in any case, and the perfectly level surface does not lend itself readily to the construction of settling tanks at an elevation to supply sprinkling filters by gravity. Apparently it would be necessary either to lift the settling tanks at great expense, or else to pump the sewage a second time in passing from the settling tanks to the filters.

Certainly the purification of the sewage by methods similar to those contemplated for Paterson would hardly involve an additional cost of less than 50 cents per capita. Adding this to the 95 cents per capita estimated for the crude discharge makes the total cost of the trunk sewer system with purification works $1.45 per capita annually. This is more than the estimated cost to Paterson of treating her sewage separately.

Putting it in another way, Paterson cannot afford to join a trunk sewer project if the terminus of the sewer is to be at a purification plant where all the sewage is thoroughly purified before being discharged. On the other hand, if the trunk sewer is allowed to be discharged into New York Bay or Newark Bay, or Kill Von Kull, it will clearly be more economical for Paterson to join the project on the basis suggested than to build independent works of her own.

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(1) Passaic Valley Sewerage Commission Report, 1902, page 23. A project and estimate was made by Mr. Jas. Owen, M. Am. Soc. C. E., for the Commission.

## FINANCIAL COMPARISON.

Bringing together the most important financial data in tabular form we have :

| | Total cost for the trunk sewer project. | Paterson's proportion of trunk sewer cost on basis of valuations of 1905. | Corresponding cost for separate works. |
|---|---|---|---|
| Total cost of works suitable for a population 2.25 times as great as that of the census of 1905. | $13,323,000 | $2,292,000 | $3,028,000 |
| Cost of those parts to be constructed at once... | 10,623,000 | 1,827,000 | 2,428,000 |
| Capital charge on those parts at 5 per cent ... | 531,000 | 91,400 | 121,400 |
| Cost of operation for population of 1910....... | 153,000 | 29,670 | 61,920 |
| Cost of storm water separation................ | | 12,900 | 12,900 |
| Total cost for 1910....... | $684,000 | $133,970 | $196,220 |
| Through a series of years the average capital invested per capita is... | $14.00 | $12.40 | $16.00 |
| Interest and sinking fund charges on same at 5 per cent ........... | 0.70 | 0.62 | 0.80 |
| Operating expenses....... | 0.23 | 0.23 | 0.48 |
| Storm-water separation... | 0.00 | 0.10 | 0.10 |
| Total annual per capita cost | $0.93 | $0.95 | $1.38 |
| Excess cost of separate disposal works......... | | | 0.43 |
| Equal to 45 per cent. | | | |

## ADEQUACY OF THE PROPOSED TREATMENTS.

The trunk sewer, following Mr. Hering's plan, with an outlet in New York Bay, or changed to have its outlet in Kill Von Kull, coupled with the necessary authority duly exercised to require the connection of all manufacturing establishments and private sewers and drains, will effectually stop the pollution of the Passaic river.

The local purification plant for Paterson, as herein proposed, coupled with adequate means for the collection of the polluting portions of manufacturing waste, will effectually stop Paterson's share of the pollution of the Passaic river; and so far as this is concerned it will be fully as effective as the construction of the trunk sewer.

The local treatment has the advantage over the trunk sewer that it allows the continued flow of the water through its natural channels, and so tends to maintain the current and volume of the river.

## GENERAL CHARACTER OF THE POLLUTION OF THE PASSAIC RIVER.

The Passaic river is dirty. The comfort and convenience of the residents along its banks require that it should be cleaned. Cleaning it is a matter of general cleaniness and comfort rather than of public health. The odors which arise from decomposing sewage do not cause typhoid fever or small-pox or scarlet fever or any other contagious disease. They may, and often do, reduce the comfort and happiness, and consequently, in a sense the health, of the people subject to them, but it cannot be maintained that they cause serious sickness. If it were a matter of public health there are other reforms which could be carried out at less cost, which would do far more good.

The present condition of the river is such that it is not pleasant to bathe in it or to use it for boating purposes, or to live too near its banks; and the feeling that it is unhealthful, even though not supported by scientific evidence, weighs with those who have to do with it. These conditions reduce the availability and value of the shore of the river for many purposes, and for these reasons it is worth while to clean the river without reference to public health.

**Points of Pollution.** The Passaic river is polluted by the discharge of sewage and manufacturing wastes and other refuse, all the way from Little Falls to Newark bay, but there are two points where the pollution is so much greater than elsewhere that they require special mention. These are Dundee Lake, which is polluted by the sewage and wastes of Paterson so as to be extremely dirty; and the river opposite and below the center of Newark, which is polluted by similar discharges from Newark and from towns which discharge their sewage to the river through Newark. In these two general localities the condition of the river is far worse than at many intermediate points. Possibly the river below Passaic might be added as a third point of special pollution.

The relative locations of the two cities are such that more of the people of Newark are near the river and suffer from a given pollution than is the case of Paterson.

At Belleville the water of the Passaic, in its raw state, was used for drinking purposes by Jersey City as recently as 1897, even though at that time in Dundee Lake and opposite Newark the river had become extremely offensive.

The condition at Dundee Lake must be attributed to the sewage and wastes of Paterson, and it is Paterson which principally suffers from these discharges. And the discharges of Newark and the towns reaching the river through Newark are principally responsible for the conditions opposite Newark.

Paterson's sewage is a contributing cause to a slight extent to the conditions at Newark, but it is only to a slight extent. The river at Newark would not be materially improved by stopping the discharges from Paterson; and if the lower discharges were removed, leaving only Paterson's, there would not be the slightest nuisance in the river opposite Newark.

While the cleaning of the whole of the Passaic river is therefore one problem, and it is no doubt best to take it up all at one time and to specify the same date for cleaning all parts of the river, the problems are in reality very largely local ones, and both Paterson and Newark suffer principally from their own wastes.

## AS TO COLLECTING MANUFACTURING WASTES.

The pollution of the Passaic river is caused, first, by domestic sewage discharged through the public sewers; and second, by manufacturing wastes, sewage and other impurities discharged directly to the river or through private sewers. To clean the river it is necessary to stop all pollutions. It will not suffice to take out of the river the sewage from the public sewers. Adequate provision must also be made for stopping other pollutions. This is a matter of much importance and difficulty. The discharges from the mills are not directly injurious to public health, and it is not fair to ask the manufacturers to incur expense on that ground. New laws will very likely be required, and such laws should be adequate to deal effectively with the situation.

Some of the manufacturing establishments produce great volumes of wastes that are difficult to treat; and the expense of handling them or removing them is as great as that of taking care of the domestic sewage from a large population. Other manufacturing establishments of corresponding size and capital, and paying corresponding taxes, produce substantially no wastes requiring treatment. Is the city or the drainage district to take without cost to the mills that produce them, manufacturing wastes representing great expense in removal and handling, or are the costs to be assessed upon the industries which produce the wastes and which profit by their production? (1)

The whole question is one requiring much study. It is practically a new question in America, and an adequate solution of it must be reached before the Passaic can be adequately cleaned.

## QUESTIONS OF LAW, FINANCE AND POLICY.

It is not possible to discuss adequately in this report questions of law, finance and policy, as many of these questions depend upon the actions which cannot now be foreseen; but it is clear that such questions must be considered before a final decision as to the best method of purifying the Passaic river is reached.

The right of the city to purify its sewage by works outside of it own limits; the right of a district to be created by Act of Legislature to dispose of its sewage outside of its own limits; and in either ease the rights of property owners to object to any nuisance or damage occasioned by such disposal, will all have to be considered. (2)

The ability and disposition of all parties to a trunk sewer agreement or bill to join with Paterson upon a scheme in every way satisfactory is clearly an indispensable preliminary to a trunk sewer arrangement.

The ability to handle financially the project that may be adopted must be ascertained; and apparently in any event special action by the Legislature will be required, for the present debt limit would otherwise make it impossible to raise the necessary funds.

At the present time there is a good deal of uncertainty as to just what the trunk sewer project is. Proposals for modifying in a fundamental way the arrangement last proposed have been made, but these proposals have not taken the shape of substituting an equally definite project for consideration.

The question as to where the sewage is to be discharged is not yet settled.

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(1) Mr. Whipple makes some statements as to English practice in Appendix II; page 35.

(2) I understand that you are securing legal opinion upon these points.

Clearly it would be unwise for Paterson or any other municipality to enter into a joint project committing her for a long term of years to a particular system of sewage disposal, and to very great expense for it, without having the whole project put in definite shape, with full assurance as to the legality of the whole proposed procedure.

There are matters which Paterson cannot fix by herself. They must be arranged by agreement with other municipalities interested, and such agreements must not conflict with the laws of the State or of the United States; and further, the approval of the State Legislature and of the Governor must be obtained.

My recommendations, therefore, are based upon the supposition that reasonable and satisfactory arrangements will be possible for all these matters; and should difficulties be encountered, which would modify the grounds for the recommendations, then they will have to be reconsidered; and I have endeavored to put the reasons for the recommendations in such shape as to enable you to apply them to such other conditions as may arise.

## RECOMMENDATIONS.

In view of all the facts and circumstances as I have found them, and upon the supposition that a full, just and lawful arrangement with the other municipalities upon the Passaic river is reached, acceptable to the Legislature and to the Governor, I believe that the interests of Paterson will be best served by joining with other municipalities in the construction of a trunk sewer to take the sewage from the entire district requiring sewage disposal facilities in the Lower Passaic Valley to a point of adequate sea-water dilution, either in New York Bay or in Newark Bay near the Kill Von Kull.

I believe that this arrangement will be substantially better for Paterson than the separate local purification of her sewage.

If, however, great obstacles to this arrangement should be found, or if it should be necessary to purify the sewage collected in such a trunk sewer before discharging it into salt water, then clearly it will be for Paterson's best interests to purify her own sewage near home; and the general plan outlined in this report and shown by the plans accompanying it would be the best one for her to adopt.

Respectfully submitted,
ALLEN HAZEN.

# APPENDIXES

### APPENDIX I.

# COMPOSITION OF PATERSON SEWAGE.

By George C. Whipple.

**Introduction.** In designing works for the purification of sewage it is necessary to know at the outset the character of the sewage to be dealt with. Where the sewage is entirely of a domestic character it is possible to estimate its ingredients with a considerable degree of accuracy, but in the case of a manufacturing city like Paterson the character of the sewage may be so altered by the discharge of waste liquors from the manufacturing establishments that it would be unsafe to design purification works without making a careful investigation as to the amount and character of these wastes. This subject was therefore taken up at the very beginning of the present investigation.

The sewage of a city, where the combined system of sewerage is used, consists of (1) the public water supply, soiled by the waste products of human beings; (2) a certain amount of ground water, which leaks into the sewers and which is usually more or less polluted; (3) an amount of wash water from the streets, roofs of houses, etc., which varies both in quantity and quality according to the rainfall; and (4) the waste waters from manufacturing establishments soiled in various ways according to the nature of the industries.

Sewage has to be considered from two standpoints—namely, its composition and its concentration, or strength. The first of these deals with the relative quantity of the various ingredients; the second, with the extent to which these ingredients are diluted with water. To these may be added a third factor—namely, the condition of the sewage with respect to its decomposition, but this can usually be forecasted if the age of the sewage at the time when it reaches the purification works is known.

Inasmuch as the volume and strength of the sewage are variable factors, which fluctuate from day to day and even from hour to hour, and as the capacity of certain parts of purification works depends to a considerable extent upon the total volume of material carried to the works, it is often found desirable to combine the data for composition and concentration so as to obtain single quantities which are more convenient for practical use. Thus, instead of using analyses expressed in parts per million and volumes of sewage expressed in million gallons per day, it is often better to reduce the results to "pounds per day" of each of the various constituents of the sewage, or to "grams per capita daily." These data are very serviceable in comparing the operation of various processes of purification in different cities and are therefore most helpful in designing new works.

**Constituents of Sewage** The most important constituents of sewage which it is necessary to know in planning for sewage purification works are the amount of suspended matter, mineral and organic; the total amount of nitrogenous matter, especially the organic nitrogen; and the fatty substances. The analyses generally give figures for total solids, volatile matter and fixed residue, both in suspension and solution; organic nitrogen and nitrogen as free ammonia, nitrites and nitrates (often nitrogen as albuminoid ammonia is given instead of organic nitrogen); oxygen consumed, taken as a rough measure of the carbonaceous matter; chlorine; alkalinity (or acidity); and the number of bacteria. Sometimes the mineral constituents are given in greater detail and also determinations of dissolved oxygen, free carbonic acid, etc. In the case of trade wastes, special determinations of tannin, logwood, acids, soaps, fats, etc., are desirable.

The constituents of domestic sewage are already known with a fair degree of accuracy. Many calculations have been made showing the amount of organic matter, nitrogen, phosphates, etc., in foecal matter. The results vary considerably, partly because of the conditions under which the analyses were made and partly on account of the use of different methods of analysis.

From a study of the percentage composition of foecal matter of persons of all ages, as given by twelve different authorities, figures representing the average amounts of certain constituents have been calculated. They are expressed in grams per capita daily and are given in the first line of the following table.

Domestic sewage contains not only excremental matter but various other substances which tend to increase the amount of mineral and organic matter. Wanklin and Cooper estimated that from five to ten grams of soap are used per capita daily, and about 90 per cent. of this is organic matter. Paper probably amounts to two or three grams per capita daily. The data are too meagre, however, for obtaining reliable synthetic values for the constituents of domestic sewage, and it is better to rely upon analyses of samples of sewage collected from various cities under different conditions. The figures given in the following table represent the results of a study of many such analyses. The cities from which these analyses were taken were divided into four groups, (1) those in which the sewage was entirely domestic, (2) those in which domestic sewage was diluted with more or less polluted ground water, (3) those in which the domestic sewage was mixed with a certain amount of street wash (combined sewerage systems), and (4) those in which the sewage contained a considerable amount of manufacturing wastes.

ESTIMATED CONSTITUENTS OF SEWAGES.
(Grams per capita daily.)

| | Total Solids. | Organic. | Mineral. | Chlorine. | Nitrogen. | Albuminoid Ammonia. | Free Ammonia. |
|---|---|---|---|---|---|---|---|
| Foecal Matter | 70 | 50 | 20 | 7 | 8 | .. | .. |
| Domestic sewage | 110 | 60 | 50 | 10 | 10 | 1.4 | 6.4 |
| Domestic sewage plus polluted ground water | 170 | 70 | 100 | 20 | 11 | 1.7 | 7.0 |
| Domestic sewage plus street wash | 220 | 100 | 120 | 25 | 13 | 2.0 | 8.0 |
| Domestic sewage plus manufacturing wastes | 220 to 500 | 100 to 200 | 120 to 300 | 25 to 50 | 13 to 15 | 2.0 to 4.0 | 5.0 to 10.0 |

It will be seen from the above figures that the effect of trade wastes on the character of the sewage is very great. As a matter of fact, the figures given in the above table for this class of sewages do not indicate the extreme conditions, but are taken as representing those which generally obtain. Until our general information on the subject of trade wastes is considerably greater than it is at present, it will be necessary to make an estimate for each individual case, based upon local conditions, in order to obtain figures which may be safely used.

In connection with the present problems at Paterson two methods of calculation have been used. The first one was based on such general data as are given in the above table, modified by what could be learned of the nature of the substances now being discharged from the various manufacturing establishments. The second method was based upon analyses of the sewage of the city, samples being collected at the mouths of the various sewers and at various points in the Passaic river above and below the city.

**Public Water Supply.** The public water supply of Paterson is furnished by the Passaic Water Supply Company, a corporation affiliated with the East Jersey Water Company. The water is derived from the Passaic river at Little Falls, and is filtered by means of a mechanical filter. It is clear, almost colorless, and moderately soft. There is nothing in its composition likely to affect the quality of the sewage with respect to its purification either favorably or unfavorably, as is some times the case where public water supplies contain excessive amounts of certain mineral salts, or are heavily laden with suspended matter.

The following may be taken as a representative analysis of the filtered water supplied to the city:

| | PARTS PER MILLION. |
|---|---|
| Turbidity | 0 |
| Color | 5. |
| Total Solids | 70. |
| Oxygen consumed | 1.500 |
| Nitrogen as albuminoid ammonia | 0.074 |
| " " free " | 0.024 |
| " " nitrites | 0.000 |
| " " nitrates | 0.080 |
| Chlorine | 3.0 |
| Hardness | 27.0 |
| Alkalinity | 20.0 |
| Iron | 0.0 |
| Bacteria per cubic centimeter | 75. |

The quantity of water used by the city of Paterson may be taken as approximately seventy-five gallons per capita. This figure is based upon data furnished by the superintendent of the Water Company. The company keeps a record of the amount of water supplied to the city each month by means of Venturi meter measurements. The consumption naturally varies according to the season, being considerably greater during the winter than during the summer.

The average consumption for the entire year at the present time is at the rate of about nine million gallons per day. In designing sewage works, however, the flows during the dryer portions of the year are what control the necessary size of the works. If the higher flows during the winter months are excluded the average consumption during the last two years may be taken as about 9.0 and 8.5 million gallons per day respectively.

During the last five years meters have been gradually introduced and this has materially lessened the consumption. When the meter system has been extended to cover all services the consumption will be still further reduced. On the other hand, the increase in wealth and changes in the character of the houses will tend to increase the legitimate use of water.

The present consumption of water for the purpose of sewage disposal may be taken as 8.4 million gallons per day, or 75 gallons per capita daily for the entire population of the city. It may be fairly assumed, moreover, that the amount of water consumption will increase in the same ratio as the population. Of course not all of this public water supply appears at the mouths of the sewers. Only about 89 per cent. of the population is provided with sewer connections, and more or less water is lost by use in boilers, by evaporation from lawns, etc. For purposes of calculation, however, it is best to ignore these matters and consider that all of the public water supply reaches the sewers.

**Population.** The population of Paterson at different dates as shown by the Census figures was as follows:

| Year. | Census. | Population. |
|---|---|---|
| 1880 | United States | 51,031 |
| 1890 | " | 78,347 |
| 1900 | " | 105,171 |
| 1905 | State | 111,529 |

Average growth per year, 3.2 per cent.
" " " decade, 36 per cent.

**Ground Water and Street Wash.** It has been estimated that the ground water leaking into the sewer amounts to about 20 per cent. of the water consumption, or about 1.6 million gallons a day. The character of this water is excellent from the standpoint of organic matter, but it is somewhat hard. The hardness is due more to carbonates than to sulphates.

If the sewerage system is changed from the combined to the separate system, as planned, it will not be necessary to consider the question of street wash, as it will then go to the river. The first washings of the streets are very impure, the later washings less so. The effect of the street washings on the average character of sewage is shown in the table on page 5.

**Trade Waste** Paterson is essentially a manufacturing city. It is the seat of the silk industry in the United States, about one-third of the total output of the country being manufactured there. There are also very large and important machine works and other industries. It is the silk industry, however, which principally demands attention in connection with the problem of sewage disposal, as it is this which contributes to the city sewers and to the river by far the largest part of the objectionable trade wastes.

**The Silk Industry.** In order to present an idea of the magnitude of the silk industry in Paterson and its relative importance as compared with other cities, the following figures are quoted from the U. S. Census of 1900:

France is the greatest silk manufacturing country in the world, the United States stands second, and Germany third. The amount of silk manufactured in England is insignificant in comparison. Silk is also made in China and Japan, but just how much is not well known. The United States manufactures about three-fourths as much silk as France.

The silk industry was begun in Paterson about 1840, but it was during the decade ending with 1870, that the great increase in the industry took place. During that decade the number of mills increased from 8 to 29, and the value of the silk products increased from $960,000 to $4,495,000. In 1900 the value of the products had increased to about $30,000,000. At the present time, according to the best available data, there are about 238 manufacturing establishments, and the value of the annual outputis between $35,000,000 and $40,000,000.

According to the United States Census report the amount of capital invested in the silk industry in 1900 was $19,000,000, or 44 per cent. of the total capital invested in manufacturing in Paterson, and 23.5 per cent. of the total capital invested in the silk industry in the United States. The average number of wage earners was 15,943 or 53 per cent. of the total number of wage earners in the city, the operatives being about equally divided between men and women. The value of the raw materials was estimated as $14,000,000 per annum, and the number of pounds of silk manufactured as 5,400,000 (the latter figure is more than one-third of the total number of pounds manufactured in the United [States, and is probably too large. Undoubtedly some of the silk was counted more than once, that is, as silk dyed, silk thrown, and silk manufactured. On the other hand some of the silk dyed on commission and not manufactured in Paterson may not have been included.) Judged from the price of raw silk, which generally costs about $4.00 per pound, and which did cost that in 1900, the number of pounds manufactured that year was probably nearer 3,500,000 pounds.

Recent data obtained from the State Bureau of Statistics of Labor and Industry and from other sources indicate that at the present time the number of operatives engaged in the silk industry in Paterson is 28,379 during the busiest season, the average number being about 20 per cent. less than this, or 22,600. The average number of pounds of silk manufactured is about 3,000,000 per year.

The manufacture of silk involves three processes, throwing, dyeing, and weaving. These operations are generally carried on in separate establishments, though in some instances they are all done in the same mill. The following figures will give an approximate idea of the relations of these processes to each other in Paterson. They are based in part upon information furnished confidentially by many of the silk manufacturers.

| | Throwing. | Dyeing. | Manufacturing. | Total. |
|---|---|---|---|---|
| Number of establishments | 35 | 22 | 238 | 295 |
| Number of operatives (weekly maximum)..... | 1,653 | 4,785 | 21,941 | 28,379 |
| (Estimated average, 20 per cent. less)............. | 1,300 | 3,800 | 17,500 | 22,600 |
| Number of pounds of silk per operative ........ | 1,100 | 2,000 | 175 | |
| Number of pounds of silk used per annum (approximate average)......... | 1,400,000 | 7,600,000 | 3,000,000 | |

The number of pounds of silk per annum was estimated in several different ways and the figures given are those which are believed to best represent the facts. From information obtained from the silk throwers it was found that on an average one operative throws about 1,100 pounds of silk per annum. This figure multiplied by the number of operatives employed by the throwsters gave a total of 1,400,000 pounds per annum. From data given in the U. S. Census of 1900 it was shown that on an average 140 pounds of silk per annum was manufactured by each operative. In this calculation, however, the operatives included were not only manufacturers, but also throwsters and dyers, which together comprise about twenty per cent. of the total number of operatives. Making allowances for this fact it has been estimated that each manufacturing operative turns out 175 pounds of silk per annum. This figure multiplied by the number of manufacturing operatives in Paterson, i. e., 17,500, gives about 3,000,000 pounds per annum.

The data for estimating the number of pounds of silk which is dyed by one operative are not numerous. At one dye-works which was carefully studied, 2,100 pounds of silk were dyed per annum by each operative. In another it was 1,800; in a third, 3,000. The amount that is dyed per operative depends a good deal on the methods used, the color dyed, etc. It may be taken as a fair estimate for works of all kinds that one operative can dye 2,000 pounds of silk per annum, and this figure has been used in the above calculations. Multiplied by the average number of operatives engaged in dyeing in Paterson, i. e., 3,800, it gives a total of 7,600,000 pounds of silk per annum dyed in Paterson. There is some reason to believe that the numbers of operatives given in the above table are somewhat too large, and therefore that the figures reached by the above calculations are probably too high. Furthermore, it is thought that during the last few years the silk industry in Paterson has not materially increased, but has, in fact, somewhat decreased.

In estimating the amount of silk wastes to be provided for it will probably be safe to use the following approximate figures:

| | Number of pounds per year. |
|---|---|
| Silk thrown | 1,500,000 |
| Silk dyed | 7,500,000 |
| Silk manufactured | 3,000,000 |

While the silk industry in Paterson, taken as a whole, is about one-third that of the United States, the ratio of silk thrown is much less than that, and the amount of silk dyed somewhat more. In 1890 Paterson had only 16.4 per cent. of the throwing spindles of the United States, while it had 29.7 per cent. of the looms, and dyed about 75 per cent. of the raw silk used.

Pennsylvania has become the centre of the silk throwing business, as the labor, which is the principal expense of the process, is cheaper here, female operatives being employed. Until recently Paterson has dyed most of the silk used in the United States, but at present only about 70 per cent. is dyed there. The amount dyed in Paterson, however, is considerably greater than the amount manufactured. Mr. Weidmann is the largest silk dyer in the country, if not in the world, and his output is said to be from a third to a half of that of the entire city.

**Process of Silk Manufacturing.**

In order to understand the character of the silk wastes and their probable effect on the composition of the sewage of Paterson it is necessary to study the process of silk manufacturing in some detail.

Common silk fibre is an excretion of the silk moth *Bombyx Mori.* As spun by the moth the fibres are double, each one being 0.036 millimeter in diameter, and from 500 to 1,300 yards in unbroken length from each cocoon. The silk is liquid when it leaves the glands of the silk worm, but the outside layer hardens immediately on exposure to the air. This outer portion, called Sericin, or silk glue, or silk gum, has to be removed. The inner portion is the true silk fibre, or fibroin, which is used. The silk gum, that is, the part which is wasted, forms from 25 per cent to 35 per cent of the weight of the raw silk. It is supposed to have the formula the $C_{15}H_{25}N_5 O_8$ It therefore contains 17.4 per cent. of nitrogen and may be considered as a rather highly nitrogenous substance. Most of the silk used in Paterson comes from Italy and Japan. The silk is imported in skeins, the reeling of the fibres from the cocoons being done abroad. The Italian silk is yellow when received and the Japanese silk is white. The difference in color is due to differences in the gum, and after this has been removed the silk fibre is, in both cases, creamy white.

The manufacture of silk involves three separate operations—namely, throwing, dyeing and manufacturing, or weaving.

**Silk Throwing.** The first operation in the manufacture of silk consists of throwing, a sort of twisting and winding process. The silk is put into a weak solution of olive oil soap with a little neats foot oil, which softens it. The skeins are then put on the reels and the silk fibres are twisted and wound on spools. The fibres for the warp of the silk goods and for the filling are wound differently. The warp fibres, commonly called organzine, are composed of two or three filaments of silk tightly twisted together so as to make them firm. The woof fibres, or those used for the filling, are composed of four or more filaments which are loosely twisted.

The process of throwing does not involve much liquid waste. A comparatively small amount of water is used and the amount of soap and oil employed is not very large. Different kinds of silk require different amounts of soap, and there seems to be considerable difference in the amount of soap used by different throwsters. It varies all the way from one to ten per cent. of the weight of the silk. Five per cent. of the weight of the raw silk may be taken as a fair average figure, although some of the statistics furnished by the throwsters in Paterson were somewhat less than this figure. This soap is wasted, and at the present time goes into the river or into the sewers, according to the location of the mill.

The soap which is universally used is known as green soap. It is made from olive oil and about 60 per cent. of the soap is oil. The neats foot oil does not appear in the waste from the throwing process as most of it adheres to the silk. The material extracted from the silk during the throwing process is comparatively small.

**Silk Dyeing** Silk dyeing is usually carried on in a separate establishment, although this is not always the case. The dyeing is an intermediate process between throwing and weaving. In some cases, however, the goods are dyed after being made up. This is known as "piece dyeing". It is comparatively unimportant in Paterson from the standpoint of waste liquors.

When the dyer receives the silk from the throwster, the first operation necessary is that of removing the silk gum or sericin. This process is called "stripping," or "boiling off." It is accomplished by soaking the silk in a strong, hot solution of olive oil soap and washing. This process results in considerable volumes of waste liquors. It is carried on in long wooden tubs. The first strong, soapy liquor is drawn off and saved to be used again in preparing dye-baths. It contains the bulk of the soap used, together with most of the silk gum. After this liquor has been drawn off, the silk is washed in three successive baths. The first of these is strongly soapy. It will have to be taken to the sewer as it is too impure to be discharged into the river, and yet it does not contain soap enough to make a recovery process pay. The second and third baths are only very slightly soapy and they may be allowed to be discharged into the river. For most purposes all of the gum is boiled off, but for souple silks, that is, soft and pliable silks, only a part of the gum is removed, and for surah silks very little gum is removed. The soupling baths are soapy and should be discharged into the sewers. Subsequent wash waters may be allowed to go to the river.

After stripping the next operation consists in bleaching the silk if it is to be used for white or pale tints. This is done by the use of sulphurous acid or hydrogen peroxide. These baths are usually very weak and the aggregate amounts of waste liquors of this character in Paterson are comparatively small. There is no objection to allowing them to go to the river. Before the silk is dyed, or sometimes between the several operations of dyeing, it goes through a process of weighting which has for its object the increase in weight of the silk. It is said that this was first done to restore the weight of the silk gum boiled off so that the dyer could return this silk to the manufacturer pound for pound of goods received. Of late years weighting has been carried far beyond this point, and it is not at all uncommon for the dyed and weighted silk to weigh nearly twice as much as the original fibre. The average increase in the weight of the silk may be taken as about 25 per cent. It is claimed that there is a demand for these weighted silks which are heavy and which give the purchaser the idea that he is getting good material. Many believe the process to be objectionable, however, as silks, which are heavily weighted, are more likely to crack than those which are not. As a rule, black silks are more heavily weighted than those of lighter color.

The light shades of silk are weighted with tin. This is done by dipping the silk alternately into solutions of stannous chloride and sodium phosphate, and finally passing it through a solution of sodium silicate, after which it is washed and moisture extracted in a whizzing machine. This process is known in the dye-shops as "dynamiting." It involves the use of large amounts of wash waters. The silk is thoroughly washed after being treated in the dynamite bath. This wash water contains considerable amounts of valuable tin, and in nearly all establishments methods are resorted to for its recovery. The method usually used is the precipitation of the tin hydrate by the use of lime, and the separation of the precipitate by means of settling tanks and filter presses. The effluent from this process is so clean that it may be allowed to be discharged into the river. The wash water, after the sodium phosphate bath, is large in amount but unobjectionable in character. It may be discharged into the river. The wash water after the silicate bath is somewhat less in volume than the latter, but yet is quite large. It is unobjectionable in character and may be allowed to go to the river.

Goods which are to be dyed black are weighted in a different way. After being stripped the silk is put into a bath of basic nitrate of iron, which results in the deposition of iron oxide in the fibre. This bath is known as the "red iron bath." After immersion in it the silk has to be washed and the first part of the wash water contains considerable quantities of iron. This water should be taken to the sewer. The last wash water is comparatively pure and may be allowed to flow to the river. After this treatment the silk is passed through a soap bath and then immersed in a bath of potassium ferro-cyanide, or yellow prussiate of potash. This gives the silk a deep blue color due to the formation of Prussian blue. It is afterwards immersed in a weak solution of hydrochloric acid. After each of these processes the silk is washed, but the wash water is clean enough to be allowed to flow to the river. The next step is to immerse the silk in a bath of gambier and tin crystals (sometimes catechu is used instead of gambier). This adds materially to the weight of the silk as a tannate of tin is deposited on the fibre. This gambier bath is generally thrown away. It contains small amounts of tin and tannin, but not enough to necessitate its being taken to the sewer.

In certain cases silks are given an organic weighting, but apparently this method is little used in Paterson and need not be considered.

Black dyeing differs considerably from white dyeing or dyeing in colors. When silk is to be dyed white it is dipped in a weak soluution of methyl blue, which combines with the cream color of the natural silk and produces a pure white. After dyeing it is washed, passed through an acid bath, and dried. Color dyeing is done in precisely the same way as white dyeing, but of course the dyebaths used are very much stronger. Aniline colors are almost exclusively used. In all cases the spent dye liquors are wasted. These liquors are very impure as they contain not only the spent dye-stuffs but also the soap and silk gum which were in the boiled off liquor which is used for preparing these baths. They, of course, should be taken to the sewer unless some method of recovering the soap is used as mentioned below.

There are several methods used in the process of black dyeing. In one case the silk, after having been weighted first with red iron and then with the gambier and tin, is washed and immersed in a solution of logwood which also contains a large percentage of soap. This bath after having been used is wasted, and as it is foul should be taken to the sewer. This process is followed by washing and the wash water is also foul and should be taken to the sewer. The next step is to immerse the silk in a bath of pyrolignite of iron, or black iron as it is called, which serves as a mordant, after which it is washed again. The first part of this wash water is foul and should be taken to the sewer; the latter part may be allowed to flow to the river. After this mordanting the silk is put into a bath of gambier and then into soapy logwood, after which it is once more washed. These wash waters are not very foul and all but the very first portion may be allowed to flow to the river. The final part of this process consists of immersing the silk in a bath of acetic acid and lemon juice and oil, which gives it a scroop and makes it brilliant. This bath is wasted and should be put in the sewer.

In jet black dyeing no iron baths are used, but the weighting is done with tin and silica, and the dyeing with gambier and logwood. In some methods of black dyeing sumac and nut galls are used and this liquor and the first part of the subsequent wash water should be sent to the sewers. Silk is sometimes dyed black with aniline colors, in which case the process more nearly resembles the one outlined above. The above description is by no means exact and is given merely to show the complexity of the processes used. Each dyer has his own secret methods, but in a general way the process is followed as outlined.

In large dye works it is the custom to recover a part of the soap, especially from the heavy soapy liquor used in black dyeing, and use it over again. The general method of doing this is to pump all the dye liquors together into a tank and add sulphuric acid. This decomposes the soap, and after a time the separated fats rise to the surface and are skimmed off. It is seldom that all of the soap can be recovered in this way, however, and in any case the liquor after going through this process is foul, as it contains the silk gum which, as stated above, is a highly nitrogenous body. It is necessary therefore that this liquor should be taken to the sewer.

Piece-dyeing in Paterson is carried on to a very limited extent. In this process the silk is woven before it is dyed. After boiling off, during which it loses about 20 per cent. of its weight by the loss of silk gum, it goes through the usual dyeing processes, except that it is not weighted. Less water and less soap are used than in skein dyeing, each pound of silk requiring only about 250 gallons of water and half a pound of soap. In the finishing and printing operations gum-arabic, glue, starch, dextrine, etc., are used, but the total amount of these added to the sewage of Paterson is a comparatively small factor.

**Volume of Silk Dye Wastes.**

It will be seen from the above that the process of silk dyeing consists in the successive use of many different solutions, and generally the silk is washed very thoroughly between the successive processes. Consequently the total amount of wash water which is used, is very large. Speaking roughly it may be said that from 300 to 1,000 gallons of wash water are needed for each pound of silk dyed, the variation being due to the character of the dyeing. The greater part of this wash water is comparatively clean. The spent dyestuffs and the first wash water following each immersion are very foul and must be taken to the city sewers. The rest of the wash water is reasonably clean and there seems to be no reason why it may not be allowed to be discharged into the river. The processes of washing differ somewhat in the different dye-works, and in many of them it may not at first thought appear feasible to separate this comparatively clean wash water from that which is foul. There ought to be no insuperable difficulty, however, in this matter, and by properly designing the drains in the dye-works there seems to be no reason why this method of separation may not be carried on at very slight expense. By so doing it would relieve the sewers of a very large volume of water.

From data at hand it would appear that the amount of wash water necessary to be taken to the sewers from the dye works ought not to exceed 50 gallons per pound of silk dyed. If it be assumed that 7.5 million pounds of silk are dyed annually in the city of Paterson, this would make the total amount of waste liquors from the dye works about 1.25 million gallons per day. In order to be on the safe side, however, it may be advisable to place the estimate at two million gallons per day, which would be 18 gallons per capita.

### Character of Silk Dye Wastes.

The next question to be considered is the nature of the substances contained in the liquors which have to be taken to the sewers.

The most important of these are the silk gums, soap (fats), dyestuffs, logwood, tannin, iron, etc. It is not necessary to go into the question of these individual wastes very minutely, and for the practical purposes of estimating the necessary size of purification works it will be sufficient to know the total amount of solid matter, the suspended solids, the total organic matter, and the amount of nitrogen and fats. The different processes of dyeing vary so much with respect to their wastes, and the proportion of black dyeing and color dyeing varies so much from time to time, according to the changes of fashion, that it is difficult to obtain figures for these general items which will be always applicable. In the following estimates, however, liberal values have been used. They are based upon studies of the silk process at several of the large dye-works and upon the analyses of many samples of wastes kindly furnished by Dr. Hunziker, the chemist at Weidmann's dye-works.

### Total Solids and Suspended Matter.

It was found difficult to obtain reliable figures for the total amount of solid matter in the wastes from the dye-works as the liquors discharged vary greatly both in quantity and quality according to the class of work being done and the process used. What was desired was the average amount of total solids per pound of silk dyed. Calculations were made from different data in several different ways. Analyses made from the main sewer of one of the largest works gave 2.05 pounds of total solid matter per pound of silk, of which one pound, or about one-half, was in suspension. Analyses of many separate discharges from another works gave 1.5 pounds per pound of silk. Calculations based on the amount of chemicals used annually at a large silk mill in Connecticut gave 1.5 pounds.

As a general average figure for purposes of calculation the total amount of solid matter from the dye-works may be taken as 1.8 pounds per pound of silk, of which 0.8 pound, or a little less than one-half, is in suspension.

For 7,500,000 pounds of silk dyed per year, this would amount to 13,500,000 pounds per year of total solid matter and to 6,000,000 pounds of suspended matter, or 37,000 and 16,500 pounds per day respectively, or 151 and 68 grams per capita daily. If the volume of sewage is taken as 125 gallons per capita, then the amount of suspended matter would be 144 parts per million, and the total solids .319 parts per million.

**Organic Matter.** From analyses of some of the samples collected at the dye works, and from data concerning the materials used, it is estimated that about 60 per cent. of the total solids are organic and 40 per cent. mineral. On this basis the amount of organic matter discharged from the dye works in Paterson is 8,100,000 pounds a year, or 22,000 pounds a day, or 90 grams per capita daily. Probably three-fifths at least of the organic matter is in suspension and composed of particles of such size that they can be removed by ordinary filter paper.

**Fats.** The organic matter consists chiefly of soap, silk gum, and various organic dye-stuffs, organic acids, etc., which may be grouped together. The amount of soap used per pound of silk varies greatly according to the character of the dyeing. In light weight dyeing it may be less than half a pound per pound of silk; in heavily weighted black silk dyeing it may be upwards of 1.5 pounds. Taking these various estimates obtained at the different works, the average weight of soap used in Paterson may be taken as equal to that of the silk. In two of the largest works, however, a large part of the soap is recovered and used again. Assuming that one pound of soap is used per pound of silk, and assuming that 75 per cent. of the soap is recovered at works where 3,500,000 pounds out of the total 7,500,000 pounds per year of silk is dyed, the amount of soap wasted from the dye works is found to be 13,300 pounds per day, or 54 grams per capita daily. If the soap contains 60 per cent. of fats, then the fats discharged from the dye works amount to 8,000 pounds a day, or 32 grams per capita daily.

**Nitrogen.** The silk gum wasted may be taken as twenty-five per cent. of the weight of the silk, or about 5,100 pounds a day, or 21 grams per capita daily.

Subtracting the soap and the silk gum from the total organic matter (22,000—13,000—5,100-3,900) leaves 3,700 pounds per day of organic matter from other sources such as logwood, tannin, and other dye-stuffs, or 15 grams per capita daily.

The nitrogen is chiefly in the silk gum, and may be taken as about 17 per cent. of it. It thus amounts to 866 pounds a day, or 3.5 grams per capita daily.

To the above should be added the wastes from the throwing mills. On the assumption that 1,500,000 pounds of silk are thrown per year, and that 5 pounds of soap are used for each 100 pounds of silk, the total amount of soap used is 75,000 pounds a year, or 206 pounds a day, or 0.8 gram per capita daily, a figure which is insignificant when compared with those for dyeing.

Summing up the results of these estimates we obtain the following figures showing the amounts of various substances which will be contributed to the sewage of the city by the silk industries:

| | Pounds per day. | Grams per capita daily. | Parts per million with assumed volume of 125 gallons per capita. |
|---|---|---|---|
| Total Solids | 37,000 | 151 | 319 |
| Suspended Solids | 16,500 | 68 | 144 |
| Mineral Matter | 15,000 | 61 | 129 |
| Organic Matter | 22,000 | 90 | 190 |
| Silk Gum | 5,100 | 21 | 44 |
| Fats, (60 per cent. of soap) | 8,000 | 32 | 68 |
| Other Organic Matter, (such as logwood, tannin, dye-stuffs, etc.) | 3,900 | 15 | 32 |
| Nitrogen | 866 | 3.5 | 7.4 |

The suspended matter is of such a character that it would readily settle if all the dye wastes were mixed together. This tendency to precipitate is aided by the reaction of the iron and the tannin. This is exhibited in a practical manner by the heavy black deposits which cover the bed of the Passaic river below the city. It seems likely that the proportion of suspended matter which would deposit in a settling tank would be greater than in the case of those in ordinary sewage.

The dye-stuffs used are logwood and aniline dyes. In weight logwood is more than the others and its resulting effect on the appearance of the mixed wastes is probably somewhat greater. From motives of economy the endeavor is always to put as large a percentage of the dyes on the goods and to waste as little as possible. To this end dyebaths are used over and over, with the addition of new dyes, so that the amount wasted is not as great as it otherwise would be. The principal objection to the dye-wastes at present is on account of the color imparted to the river water. It may be expected that the color imparted to the city's sewage would be somewhat greater as the dilution would ordinarily be less than in the river.

The present foul appearance of the river below the city is due more to the black deposits on the bottom than to the color of the water itself. It was a continual surprise to those who collected the river samples to note how comparatively free of color the water appeared in the bottles while in the river it looked dark and offensive. If the water were freed of its suspended matter and of the oily substances contributed by the gas works it would be not nearly as bad as it now is.

In order to obtain an approximate idea of the effect of the dye-stuffs when mixed with the city's sewage, the experiment was made of diluting some of these wastes and noting the point at which the color was practically invisible when observed through a column of liquid one foot high. The following were some of the results obtained:

| | Dilution at which the color was Faint. | | Practically unnoticeable. | |
|---|---|---|---|---|
| Dye-stuff. | Before Filtering. | After Filtering. | Before Filtering. | After Filtering. |
| Mixture of purple and blue aniline dyes, | 1:400 | 1:200 | 1:1000 | 1:500 |
| Mixture of several gum aniline dyes, | 1:000 | 1:500 | 1:10000 | 1:2000 |
| Logwood wash water, | 1:500 | 1:500 | 1:1000 | 1:1000 |

Estimates based on the above figures, taking into account the quantity of each liquor wasted, showed that the dilution of the colored aniline dye liquors when mixed with the sewage of the city would be between 1:300 and 1:400. The average daily sewage would therefore have a purple or violet color due to these dyes. The color imparted by the logwood to the sewage would be brown, and this would be no more conspicuous after dilution than the same amount of color observed in swamp or peaty waters, provided that the suspended matter were removed. The effect of the purification by the method described in the report would be to remove the greater part of the suspended matter and to reduce a certain amount of the color in solution. The effluent from the works would have but little objectionable color, although there would be at all times a noticeable brown hue and occasionally a faint purple.

The fats would probably prove to be the most troublesome constituent added to the sewage by the dye-works. They would tend to clog the pores of the filter. Some of them would doubtless be eliminated in the settling tanks. It seems likely that, as the recovery of the fats at the dye-works is a profitable undertaking, or as it at least pays for itself, the practice will become much more common than it is today. It would seem as if, by good management the amount of soap wasted might be reduced by one-half.

There is no reason to believe that the trade wastes will interfere with the bio-chemical reactions which take place in the different processes of sewage purification. Certain of the wastes taken by themselves might tend to do so, as, for instance, acids, compounds of tin, etc., but the resultant mixture of the whole would have no prejudicial influence.

## Comparison of the Silk Industry with the Woolen and Cotton Industries.

The silk industry is not as well known by sanitarians in this country as the woolen and cotton industries. Those who are familiar with the last two are likely to get an erroneous idea of the effect of Paterson's manufacturing waste on the sewage of the city if they judge it by their ordinary standards. The following figures taken from the U. S. Census for 1900 show that in round numbers the weight of wool manufactured per operative is 17 times as great as the weight of silk, and the weight of cotton is 40 times as great.

In the woolen manufacture of the whole United States for the year 1900, 394,000,000 pounds of wool were used, the total number of operatives being 159,000, an average of 2,480 pounds of wool per operative. In 1890 the average amount of wool per operative was 2,280 pounds. This is exclusive of knit goods.

In silk manufacturing for 1900, 9,760,000 pounds of raw silk were used by 65,416 operatives, an average of 150 pounds of silk per operative. In 1890 the corresponding figures were 6,376,000 pounds of silk and 49,382 operatives, an average of 129 pounds of raw silk per operative.

In the cotton manufacture for 1900 the cotton used was 1,814,000,000 pounds and the average number of operatives was 298,000, the average number of pounds of cotton per operative being 6,100. In 1890 the corresponding figures were 1,117,000,000 pounds of cotton and 219,000 operatives, or 5,100 pounds of cotton per operative.

The amount of the three raw materials used per operative for the two census years was as follows :

| Year | Cotton | Wool | Silk |
|---|---|---|---|
| | Pounds per operative. | | |
| 1900 | 6100 | 2480 | 150 |
| 1890 | 5100 | 2280 | 129 |
| | | Ratio | |
| 1900 | 41 | 16.6 | 1 |
| 1890 | 39 | 17.7 | 1 |

**Breweries.** There are six breweries in Paterson and the annual output is 230,000 barrels, of which about two-thirds is beer and one-third ale. This is equivalent to 767 barrels a day.

Through the courtesy of Mr. John Hinchliffe an opportunity was given to investigate the wastes resulting from the brewing process. From data obtained at the Hinchliffe brewery the total amount of water used for washing, refrigerating, etc., was estimated as about 20 gallons for each gallon of beer or ale. The largest amount of water is used and wasted in the malting department and the next largest in the refrigerating plant. More or less water is used for washing the barrels. Comparatively little is used in the brewing process proper. From the best available data it has been estimated that for each gallon of beer there is required two gallons of water for washing barrels, cleaning tubs, etc.; 5 gallons for refrigeration, and 13 gallons for various operations connected with the malting process, including all water used for washing floors, tanks, etc. In a paper on brewing by Dr. Wilson of the West Riding Rivers Board, England, some figures are given for the amount of water used in brewing. They vary from 1.5 to 7 gallons of water for each gallon of beer. Assuming that water is used at the estimated rate, the total amount of water used by the brewers in Paterson would be in round numbers about 450,000 gallons per day, or about 4 gallons per capita.

From the results obtained by analysis of samples of wash water collected at the breweries it has been estimated that the amount of organic matter put into the Paterson sewers from the breweries is about 150 pounds per day, of which 25 pounds is nitrogen. This is equivalent to about 0.1 gram per capita daily. As no samples could be obtained which fairly represented the malting process it is quite likely that this figure is too low, and probably it ought to be doubled. It will be seen, however, that the amount of organic matter from the breweries is very small indeed when compared with that from the silk dye works. Although the amount of organic matter is small, yet its character is such that it is liable to increase the odor of the sewage. It contains considerable quantities of yeast and reaches the sewer in a fermented condition.

**Gas Works.** This subject is discussed by Mr. Clark in Appendix No 4.

**Other Industries.** Only about one-half of the manufacturing carried on in Paterson is connected with the silk business. There are in addition large locomotive and steel works, foundries, machine shops, etc., where several thousand men are employed. Data furnished by the Board of Statistics show that there are 13 establishments employing more than 100 men each, and 21 employing between 25 and 100. Most of these places, however, contribute little or nothing in the way of manufacturing wastes to the sewage of the city. There are three shirt factories employing nearly 1,000 operatives, from which more or less wash water is discharged into the river. There are also three slaughter houses and packing establishments where 75 operatives are employed. There are also several velvet and plush manufactories, in some of which printing is done, but the amount of liquid waste from these is a negligible quantity.

**Analyses of Samples of Sewage.** On April 18-20, 1906, samples of sewage were collected from the mouths of the principal sewers in Paterson at the same time that gaugings were made of the flow. From the analysis of these samples and the data as to the volume of sewage flowing at the time it was possible to calculate the number of pounds per day of sewage matter discharged by the city sewers. Inasmuch, however, as each sample represents only one particular moment in the day's flow, and as the sewage changes constantly in quantity and quality, the data derived from the analyses must be considered as only approximate. By applying a suitable factor to the results, however, an estimate has been obtained which represents the character of the average sewage with an accuracy sufficient for present needs. The results of the analyses and the calculations therefrom are given in Table 9. Sixteen sewers were examined, representing about 85 per cent. of the total volume of sewers. Some of the other sewers were either inaccessible or were so affected with backwater from the river that satisfactory samples and flow could not be obtained. From the results given in this table the following per capita constituents of the sewage were obtained, and for comparison they are placed side by side with the average figures for the sewage of manufacturing cities as set forth on a previous page.

SEWAGE CONSTITUENTS. GRAMS PER CAPITA DAILY.

| | Paterson Sewage (From analyses made April 18-20, 1906.) | Domestic Sewage and Ground Water. | Sewage of Manufacturing cities. |
|---|---|---|---|
| Total Solids........ | 360 | 170 | 220 to 500 |
| Organic Matter..... | 189 | 70 | 100 to 200 |
| Mineral Matter..... | 171 | 100 | 120 to 300 |
| Suspended Solids... | 69 | .. | |
| Chlorine.......... | 29 | 20 | 25 to 50 |
| Nitrogen.......... | 13.0 | 11 | 13 to 15 |
| Albuminoid Ammonia | 2.5 | 1.7 | 2 to 4 |
| Free Ammonia..... | 5.8 | 7.0 | 5 to 10 |
| Fats.............. | 63 | 20 | 20 to 50 |

It will be seen from these figures that the present sewage of Paterson is not much stronger than the ordinary limits for manufacturing cities. It must be remembered that the above figures do not include the trade wastes discharged directly into the river. The effect of the silk dye-house wastes is seen in the large amount of fats. In five out of sixteen sewers these dye-wastes conspicuously colored the sewage.

**Analyses of Samples of River Water.** In order to ascertain approximately the amount of sewage and trade wastes discharged by the city of Paterson into the Passaic river three series of samples were collected on January 19th and 20th; on February 17th, 18th, and 19th; and on June 12th, 1906.

The first series on January 19th and 20th, 1906, was taken at a point just above the Passaic Falls, above which the city contributes little or no sewage to the river. The second series was taken at the Nineteenth street bridge which is below all the important sources of pollution from the mills. It is not, however, below all of the city sewers. The third series was taken at the Dundee Dam, which is below all the city sewers. The samples at all three stations were collected hourly for twenty-fours beginning at 10.00 a. m. on January 19th. Each sample was a composite of three portions, one portion taken at either side of the river and one in the middle.

The hourly samples were analyzed for turbidity, color, odor chlorine and alkalinity. Portions of them were then combined to obtain representative samples for the day and night, the day period covering the hours from 7.00 a. m. to 6.00 p. m. and the night period from 7.00 p. m. to 6.00 a.m. These samples were analyzed fully and the results are given in Tables 1 and 2. The flow of the Passaic river was observed during the time when the samples were being collected, and the discharges kindly furnished by Mr. John H. Cook, Hydraulic Engineer of the S. U. M.

On the same day samples of water were collected at five different points on the river in order to show how the character of the water varied up and down the stream. The result of these analyses are given in Tables 3 and 4.

The second lot of samples was collected on February 17th, 18th and 19th. (See Tables 5 and 6.) February 18th was Sunday and the object of this series was to obtain data during a time when little orno wastes from the silk dyeing works were being discharged into the river. The samples at the Passaic Falls and the Nineteenth street bridge were taken hourly from nine o'clock Saturday evening, February 17th, to 8 o'clock, Sunday evening, February 18th. Those that were collected at the Dundee Dam were taken twelve hours later, the results of the previous observations having shown that it took substantially twelve hours for the water to pass to this point from the city. The results in this instance were disappointing in that the water still showed traces of the manufacturing wastes, and clearly the time allowed was not sufficient.

The third lot of samples was collected on June 12th. (See Tables 7 and 8.) Fewer samples were taken than before and some were collected at the Dundee Dam. Two samples were collected above the Passaic Falls, one representing the day flow and one the night flow. Eighteen hourly samples were collected at the Nineteenth street bridge.

The samples collected at the Nineteenth street bridge on January 19th and 20th showed great differences in character between the day flow and the night flow of the river. Thus, the turbidity at the Nineteenth street bridge, which is below most of the manufacturing wastes, varied from seven during the night to forty-eight in the day time. The average turbidity of the night flow was fourteen and of the day flow thirty-five. Similar differences were noticed in the chlorine and alkalinity, but they were less conspicuous than in the case of the turbidity. During the night the color of the water was substantially the same below the city as it was at the Passaic Falls, but during the day time nearly all of the samples had a blueish or reddish color due to the discharge of dye wates into the river.

The hourly samples at the Dundee dam showed similar changes, but they were less conspicuous and occurred at different hours of the day from those just below the city. This was due, of course, to the time required for the water to flow from Paterson to the Dundee dam. The turbidity at the Dundee dam was higher during the night run than it was during the day run. This was also true of the color, chlorine and alkalinity.

All the samples taken from the river between the gas works and Dundee dam possessed a tarry odor, due unquestionably to the discharge of waste material from the gas works. The intensity of this odor varied considerably at different times during the day and night, showing that the discharge was intermittent.

As would be naturally expected the samples collected on Sunday, February 18th, showed smaller differences between the day run and the night run. Thus, at the Nineteenth street bridge the turbidity of the water during the day time was ten and during the night time eight, while the colors were twenty-one and sixteen respectively. Furthermore, the amount of waste discharged from the gas works was apparently much less, as only a few of the Sunday samples possessed tarry odors. The samples collected at the Dundee dam on Sunday and Monday showed the effect of the trade wastes discharged on Saturday. All of these samples were more or less colored with dye wastes and possessed tarry odors.

The samples collected on June 12th showed somewhat lower results for the amounts of polluting matter discharged into the river than those on January 19th. This was due to a considerable extent to smaller amounts of waste material from the gas works. The samples collected at the Nineteenth street bridge were not affected to any great extent with tarry odors, as they had been on previous dates.

From the analyses of the river water samples, and from the data as to the amount of stream flow confidentially furnished, calculations were made which showed the total amount of polluting matter discharged into the streams. The data obtained on the different days were somewhat conflicting, but in the main they substantially corroborated the figures already given for the amount of nitrogen, fat, etc. The amount of solid matter, calculated from the river analyses, was greater than that obtained by calculation from the city sewage. A large part of this was not of a character to seriously pollute the river. That part of it due to the gas works can be disposed of on the premises and may be disregarded in connection with the present study. Much of it is in solution and can be allowed to enter the stream without seriously affecting the quality of the river water.

Although the data obtained from the analyses of samples of sewage and river water were, of course, taken into consideration in judging the probable amount of matter which will be present in the future sewage of Paterson, i. e., when the sewage from the different sections of the city and the wastes from the dye-works shall be mixed together, greater weight was given to the data obtained from the dye-works themselves and to the general knowledge of what constitutes the sewage of a large city.

## TABLE NO. 1.

## RESULT OF ANALYSES OF HOURLY SAMPLES FROM THE PASSAIC RIVER ABOVE AND BELOW PATERSON, ON JAN. 19 AND 20, 1906.

| Date. | Hour. | Stream discharge at Passaic Falls. cu. ft. per sec. | TURBIDITY. | | | COLOR. | | | ODOR. | | | CHLORINE. | | | ALKALINITY. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | At Passaic Falls | At 19th street Bridge | At Dundee Dam. | At Passaic Falls | At 19th street Bridge | At Dundee Dam. | At Passaic Falls | At 19th Street Bridge | At Dundee Dam. | At Passaic Falls | At 19th street Bridge | At Dundee Dam. | At Passaic Falls | At 19th Street Bridge | At Dundee Dam. |
| 1906. | | | | | | | | | | | | | | | | | |
| Jan. 19, | 10 A. M. | 1634 | 6 | 14 | 5 | 29 | 38 sl. rd | 32 | 0 | 3 t | 1 t | 2.5 | 5.7 | — | 25 | 23 | — |
| " " | 11 " | 1634 | 9 | 17 | 5 | 30 | 35 | 32 | 0 | 1 t | 2 d | 3.1 | 6.3 | 5 5 | 21 | 26 | — |
| " " | 12 M. | 1634 | 8 | 41 | 5 | 32 | 50 rd. | 33 | 0 | 1 m | 1 t | 2.8 | 8.8 | 5.9 | — | 25 | 28 |
| " " | 1 P. M. | 1652 | 7 | 34 | 5 | 32 | 36 | 32 | 0 | 2 t | 1 t | 2.8 | 7.9 | 6 4 | 26 | 25 | 24 |
| " " | 2 " | 1652 | 7 | 36 | 6 | 33 | br. rd. | 31 | 1 d | 2 t | 1 t | 2.5 | 8.4 | 4.6 | 24 | 44 | 29 |
| " " | 3 " | 1652 | 8 | 38 | 5 | 31 | sl. p | 32 | 0 | 2 t | 2 t | 2 8 | 7.0 | 5.5 | — | — | — |
| " " | 4 " | 1652 | 8 | 41 | 5 | 34 | sl. rd. | 32 | 0 | 2 t | 4 t | 2 5 | 7.0 | 5 5 | 19 | 21 | — |
| " " | 5 " | 1652 | 6 | 48 | 6 | 32 | br. rd. | 33 | 1 d | 3 t | 3 t | 2.5 | 7.0 | 5.9 | 22 | 37 | — |
| " " | 6 " | 1652 | 6 | 34 | 9 | 33 | 38 | 31 | 0 | 1 t | 2 t | 2.5 | 7.5 | 6.4 | 20 | 29 | 23 |
| " " | 7 " | 1294 | 7 | 24 | 6 | 32 | 36 p. | 35 | 0 | 1 t | 2 t | 2.5 | 5.3 | 6.4 | 25 | 27 | 23 |
| " " | 8 " | 1294 | 6 | 24 | 10 | 34 | 35 p. | 34 | 0 | 4 t | 2 t | 2.8 | 5 3 | 6.4 | 20 | 23 | 30 |
| " " | 9 " | 1294 | 6 | 24 | 9 | 32 | 33 | 33 | 0 | 2 t | 2 t | 2.8 | 6.3 | — | 22 | 21 | — |
| " " | 10 " | 1271 | 6 | 24 | 7 | 32 | 28 | 34 | 0 | 3 t | 1 t | 3 1 | 5.3 | 5 5 | 21 | 23 | 31 |
| " " | 11 " | 1336 | 5 | 18 | 7 | 32 | 32 | 34 | 0 | 4 t | 2 t | 2.8 | 5.3 | 5.5 | 25 | 29 | 31 |
| " " | 12 " | 1336 | 5 | 9 | 10 | 31 | 32 | 38 p. | 1 d | 2 t | 2 t | 3,1 | 6 3 | 6 4 | 20 | 20 | 23 |
| Jan 20, | 1 A. M. | 1412 | 6 | 9 | 9 | 32 | 32 | 34 p. | 0 | 4 t | 2 t | 2.8 | 5.3 | 6.4 | 22 | 24 | 23 |
| " " | 2 " | 1490 | 6 | 7 | 9 | 32 | 34 | 36 | 0 | 2 t | 2 d | 3.1 | 6 3 | 6 4 | 24 | 24 | 29 |
| " " | 3 " | 1490 | 6 | 7 | 10 | 32 | 33 | sl.rd. | 1 d | 2 t | 2 t | 2 5 | 4.8 | 6.8 | 25 | 23 | 23 |
| " " | 4 " | 1572 | 6 | 7 | 9 | 31 | 34 | sl.rd. | 1 d | 1 t | 2 t | 2.5 | 6.3 | 6.4 | 21 | 27 | 31 |
| " " | 5 " | 1656 | 6 | 7 | 7 | 30 | 32 | 38 p. | 0 | 2 t | 3 t | 3.1 | 5.7 | 6.4 | 26 | 20 | 26 |
| " " | 6 " | 1656 | 6 | 7 | — | 31 | 34 | — | 0 | 4 t | 2 t | 3.1 | 6.3 | 6.4 | — | 24 | 30 |
| " " | 7 " | 1634 | 7 | 48 | 7 | 32 | br. rd. | rd. | 0 | 3 t | 2 t | 2.5 | 6.3 | 5.9 | 28 | 25 | 28 |
| " " | 8 " | 1634 | 7 | 34 | 7 | 31 | sl. rd. | 34 | 1 d | 2 t | 2 t | 2.5 | 5.3 | 5.5 | — | 28 | 29 |
| " " | 9 " | 1634 | 7 | 41 | 6 | 31 | br. rd. | 35 | 0 | 2 t | 3 t | — | 7.9 | 6.4 | — | 30 | 27 |
| Average—Day | | 1643 | 7 | 35 | 6 | 32 | 39 rd. | 31 | 0.25 d | 2 t | 2 t | 3.0 | 7.0 | 5.5 | 22 | 28 | 24 |
| Average—Night | | 1428 | 6 | 14 | 9 | 32 | 33 | 35 sl.rd. | 0.25 d | 3 t | 2 t | 2.5 | 5.5 | 6.5 | 23 | 24 | 26 |
| Ave. Entire day, | | 1536 | 6.5 | 25 | 7.5 | 32 | 36 sl rd. | 33 | 0.25 d | 2.5 t | 2 t | 2 75 | 6.3 | 6.0 | 22 | 26 | 25 |

Abbreviations. Sl-slight; rd.-reddish; br.-bright; p.-purple; t.-tarry odor; d.-disagreeable odor.

## TABLE NO. 2.

## SUMMARY OF CHEMICAL ANALYSES OF MIXED HOURLY SAMPLES FROM THE PASSAIC RIVER ABOVE AND BELOW PATERSON. JAN. 19-20, 1906.

(Parts per million.)

| Source of sample | At Bridge above Passaic Falls | | | At 19th St. Bridge | | | At Dundee Dam | | |
|---|---|---|---|---|---|---|---|---|---|
| Date of collection | Jan. 19-20 | | | Jan. 19-20 | | | Jan. 19-20 | | |
| Hour of collection | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. |
| Physical Analysis | | | | | | | | | |
| Turbidity | 7. | 6. | 6.5 | 35. | 14. | 24.5 | 6 | 9 | 7.5 |
| Color | 32. | 32. | 32 | 39 | 33 | 36 | 31 | 35 | 33 |
| Chemical Analysis (Parts per million) | | | | | | | | | |
| Nitrogen as Albuminoid Ammonia in solution | .142 | .032 | .087 | .410 | .230 | .320 | .180 | .130 | .155 |
| in suspension | .064 | .028 | .046 | .270 | .050 | .160 | .070 | .140 | .105 |
| total | .206 | .060 | .133 | .680 | .280 | .480 | .250 | .270 | .260 |
| Nitrogen as Free Ammonia | .032 | .016 | .024 | .100 | .060 | .080 | .150 | .170 | .160 |
| Nitrogen as Nitrites | .007 | .006 | .007 | .014 | .004 | .009 | .009 | .010 | .010 |
| Nitrogen as Nitrates | .20 | .20 | .20 | .00 | .05 | .025 | .00 | .00 | .00 |
| Total Organic Nitrogen | .40 | .26 | .33 | 1.30 | .52 | 0.91 | .78 | 1.05 | .925 |
| Oxygen consumed 5 minutes | 4.90 | 4.80 | 4.85 | 11.60 | 5.50 | 8.65 | 6.00 | 7.00 | 6.60 |
| 30 " | 5.80 | 5.40 | 5.60 | 15.75 | 7.45 | 11.6 | 7.00 | 8.80 | 8.20 |
| Total residue | 83. | 66. | 74.5 | 123. | 105. | 114. | 90. | 123. | 106.5 |
| Loss on ignition | 22. | 13. | 17.5 | 42. | 28. | 35. | 16. | 17. | 16.5 |
| Fixed residue | 61. | 53. | 57. | 81. | 77. | 79. | 74. | 106. | 90. |
| Suspended solids | 4. | 3. | 3.5 | 25. | 20. | 22.5 | 2. | 4. | 3. |
| Iron | .40 | .40 | .40 | .50 | .50 | .50 | .60 | .60 | .60 |
| Total hardness | 39.5 | 34. | 36.5 | 39.0 | 51.5 | 45.3 | 39.0 | 44.0 | 41.5 |
| Alkalinity | 21.5 | 22.5 | 22. | 28.0 | 23.5 | 25.7 | 23.5 | 25.5 | 24.5 |
| Incrustants | 18.0 | 11.5 | 14.5 | 11.0 | 28.0 | 19.5 | 15.5 | 18.5 | 17.0 |
| Chlorine | 3.0 | 2.5 | 2.75 | 7.0 | 5.5 | 6.25 | 5.5 | 6.5 | 6.0 |

## TABLE NO. 3.

## PHYSICAL AND CHEMICAL ANALYSES OF SAMPLES FROM THE PASSAIC RIVER AT PATERSON, JAN. 19, 1906.

| Source of sample, Passaic River. Paterson, N. J. | West St. Bridge | StraightSt. Bridge | Sixth Ave. Bridge | Wagraw Bridge | Morlot Bridge |
|---|---|---|---|---|---|
| Hour of collection | 4.30 p m. | 2.50 p. m. | 3 00 p. m | 3.45 p.m. | 4.00 p.m. |
| Physical analysis | | | | | |
| Turbidity | 6. | 13 | 22 | 25 | 23 |
| Color | 34. | very slight red | dark | slight red | reddish |
| Odor | 3v | chemical | 4 tarry | 3 tarry | 3 tarry |
| Chemical analysis (Parts per million.) | | | | | |
| Nitrogen as Albuminoid Ammonia — in solution | .160 | .140 | .190 | .170 | .300 |
| Nitrogen as Albuminoid Ammonia — in suspension | .170 | .140 | .210 | .180 | .080 |
| Nitrogen as Albuminoid Ammonia — total | .330 | .280 | .400 | .350 | .380 |
| Nitrogen as free ammonia | .070 | .140 | .320 | .240 | .040 |
| Nitrogen as nitrites | .005 | .005 | .006 | .010 | 010 |
| Nitrogen as nitrates | .00 | .00 | .00 | .00 | .00 |
| Total organic nitrogen | .74 | .65 | 1.73 | 1.86 | 1.06 |
| Oxygen consumed 30 minutes | 5.60 | 7.90 | 8.30 | 10.05 | 14.70 |
| Total residue | 75. | 85. | 95. | 77. | 85. |
| Loss on ignition | 25. | 10 | 23. | 19. | 32. |
| Fixed residue | 50. | 75. | 72. | 58. | 53. |
| Suspended solids | 4. | 18. | 18. | — | — |
| Iron | .4 | 4 | .6 | .6 | .6 |
| Total hardness | 39.3 | 39.4 | 41.3 | 41.3 | — |
| Alkalinity | 20.5 | 20.5 | 22.0 | 22.5 | 22.5 |
| Incrustants | 18.8 | 18.9 | 19.3 | 18.8 | — |
| Chlorine | 4.0 | 4.0 | 6.5 | 6.0 | 5 0 |

## TABLE NO. 4.

## MICROSCOPICAL ANALYSES OF SAMPLES FROM THE PASSAIC RIVER AT PATERSON, JUNE 19, 1906.

| Source of Sample, Passaic River, Paterson, N. J. | West Street | Straight Street | Sixth Ave. | Wagraw Bridge. | Morlot Bridge |
|---|---|---|---|---|---|
| Asterionella | 52 | 40 | | | 24 |
| Fragilaria | | | | | 60 |
| Melosira | 40 | | | | |
| Synedra | 40 | 40 | 12 | 12 | 48 |
| Tabellaria | 24 | | | | 16 |
| Protococcus | | | | | 20 |
| Spirogyra | | | 40 | | |
| Coelosphaerium | 40 | | | | |
| Leptothrix | 180 | 760 | 2000 | 2000 | 640 |
| Beggiatoa | | | | 60 | 24 |
| Ciliata | 64 | 172 | 560 | 480 | |
| Synura | | 60 | | | |
| Anthophysa | 120 | 292 | 200 | 760 | 72 |
| Monas | | 1000 | 1200 | 2000 | 400 |
| Vorticella | 60 | | | | |
| Cercomonas | | 68 | | | |
| Silk fibre | 40 | 180 | | | |
| Fibres | | | 1080 | 520 | 360 |
| Epithelial Cells | | | 100 | 260 | |
| Total Organisms | 620 | 2432 | 4012 | 5312 | 1304 |
| Amorphous Matter | 900 | 1200 | 6000 | 4000 | 4000 |

## RESULTS OF ANALY

| Date. 1906. | | Hour | | Stre disch a Pass Fal Cu. per |
|---|---|---|---|---|
| Feb. | 17 | 9 | P. M. | 442 |
| " | " | 10 | " | 442 |
| " | " | 11 | " | 442 |
| " | " | 12 | " | 442 |
| " | 18 | 1 | A. M. | 442 |
| " | " | 2 | " | 442 |
| " | " | 3 | " | 442 |
| " | " | 4 | " | 442 |
| " | " | 5 | " | 442 |
| " | " | 6 | " | 442 |
| " | " | 7 | " | 442 |
| " | " | 8 | " | 442 |
| " | " | 9 | " | 442 |
| " | " | 10 | " | 442 |
| " | " | 11 | " | 442 |
| " | " | 12 | M. | 442 |
| " | " | 1 | P. M. | 442 |
| " | " | 2 | " | 400 |
| " | " | 3 | " | 360 |
| " | " | 4 | " | 360 |
| " | " | 5 | " | 360 |
| " | " | 6 | " | 360 |
| " | " | 7 | " | 360 |
| " | " | 8 | " | 360 |
| " | " | 9 | " | 360 |
| " | " | 10 | " | No obs vatio beyon this po |
| " | " | 11 | " | |
| " | " | 12 | " | |
| " | 19 | 1 | A. M. | |
| " | " | 2 | " | |
| " | " | 3 | " | |
| " | " | 4 | " | |
| " | " | 5 | " | |
| " | " | 6 | " | |
| " | " | 7 | " | |
| " | " | 8 | " | |
| Average. (Day | | | | |
| Average (Night | | | | |
| Ave. Entire day. | | | | 421 |

*g. b. = grey brow standards. t tarry odor

## TABLE NO. 6.

### SUMMARY OF CHEMICAL ANALYSES OF MIXED HOURLY SAMPLES FROM THE PASSAIC RIVER ABOVE AND BELOW PATERSON.

### FEB. 17-18-19, 1906.

(Parts per million.)

| Source of sample / Date of collection | Above the Passaic Falls Feb. 17-18 | | | At the 19th St. Bridge Feb. 17-18 | | | Above the Dundee Dam Feb. 18-19 | | |
|---|---|---|---|---|---|---|---|---|---|
| Hour of collection | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. | 7 a. m. to 6 p. m. | 6 p. m. to 7 a. m. | Ave. |
| Physical analysis | | | | | | | | | |
| Turbidity | 5. | 5. | 5. | 10. | 8. | 9. | 10. | 12. | 11. |
| Color | 12. | 20. | 11. | 21. | 16. | 18.5 | Gray brown | Gray brown | Gray brown |
| Chemical analysis (Parts per million) | | | | | | | | | |
| Nitrogen as Albuminoid Ammonia in solution | .114 | .122 | .121 | .200 | .230 | .215 | .270 | .360 | .325 |
| in suspension | .076 | .076 | .076 | .130 | .400 | .265 | .240 | .140 | .190 |
| total | .190 | .204 | .197 | .330 | .630 | .485 | .510 | .500 | .505 |
| Nitrogen as Free Ammonia | .010 | .032 | .022 | .200 | .150 | .175 | .150 | .150 | .150 |
| Nitrogen as Nitrites | .008 | .007 | .0075 | .010 | .025 | .0175 | .025 | .025 | .025 |
| Nitrogen as Nitrates | .40 | .35 | .375 | .40 | .30 | .35 | .25 | .30 | .275 |
| Total Organic Nitrogen | 41 | .35 | .38 | 1.26 | 1.69 | 1.48 | 1.02 | 1.40 | 1.21 |
| Oxygen consumed 5 minutes | 3.5 | 3.9 | 3.7 | 4 6 | 5.2 | 4.9 | 7.6 | 7.9 | 7.75 |
| 30 " | 4.2 | 4.7 | 4.45 | 5.4 | 6.7 | 6.05 | 9.1 | 9.2 | 9.5 |
| Total residue | 95. | 100. | 97. | 98. | 94. | 96. | 125. | 118. | 121. |
| Suspended solids | 4. | 4. | 4. | 15. | 16. | 15.5 | 17. | 13. | 15. |
| Iron | .40 | .30 | .35 | .60 | .40 | .50 | .70 | .70 | .70 |
| Total hardness | 42 5 | 40.0 | 41.25 | 40.0 | 40 0 | 40.0 | 45.0 | 40.0 | 42.5 |
| Alkalinity | 34.5 | 32.5 | 33.5 | 35 5 | 38.5 | 36.5 | 41.0 | 37.5 | 39.25 |
| Incrustants | 8.0 | 7.5 | 7.75 | 4.5 | 2.0 | 3.5 | 4.0 | 2.5 | 3.25 |
| Chlorine | 3 0 | 4.0 | 3.5 | 4 5 | 6.0 | 5.3 | 7.0 | 7.5 | 7.25 |

## TABLE NO. 7.

### RESULTS OF ANALYSES OF HOURLY SAMPLES OF THE PASSAIC RIVER ABOVE AND BELOW PATERSON, June 12, 1906.

| Date | Hour | Turbidity | | Color | | Odor | | Chlorine | | Alkalinity | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | At Passaic Falls | At 19th St. Bridge | At Passaic Falls | At 19th St. Bridge | At Passaic Falls | At 19th St. Bridge | At Passaic Falls | At 19th St. Bridge | At Passaic Falls | At 19th St. Bridge |
| June 12 | 6.20 a. m. | | 20 | | sl. yel. | | 1d | | 8.0 | | 34.0 |
| | 7 | | 35 | | rd. pur. | | 1d | | 7.0 | | 34.0 |
| | 8 | | 26 | | sl. pur. | | 1d | | 7.0 | | 36.0 |
| | 9 | | 22 | | sl. pur. | | 1d | | 8.0 | | 35.0 |
| | 10 | | 16 | | sl. pur. | | 1d | | 9.0 | | 36.0 |
| | 11 | 12 | | 35 | | 1v | | 4.0 | | 34.0 | |
| | 12 | | 23 | | sl. pur. | | 2d | | 12.0 | | 34.0 |
| | 1 p. m. | | 25 | | sl. pur. | | 2d | | 12.0 | | 36.0 |
| | 2 | | 30 | | sl. pur. | | 2d | | 11.0 | | 35.0 |
| | 3 | | 25 | | sl. pur. | | 2d | | 9.0 | | 29.0 |
| | 4 | | 23 | | rd. yel. | | 3d | | 12.0 | | 36.0 |
| | 5 | | 26 | | sl. yel. | | 3d | | 11.0 | | 33.0 |
| | 6 | | 30 | | sl. yel. | | 2d | | 11.0 | | 32.0 |
| | 7 | | 32 | | sl. yel. | | 2d | | 12.0 | | 33.0 |
| | 8 | | 28 | | sl. yel. | | 2d | | 12.0 | | 33.0 |
| | 9 | 15 | | 34 | | 1v | | 4.0 | | 34.0 | |
| | 9.30 | | 25 | | rd. pur. | | 1d | | 10.0 | | 36.0 |
| | 10 | | 30 | | sl. yel. | | 1d | | 10.0 | | 33.0 |
| | 11 | | 27 | | sl. yel. | | 1d | | 9.0 | | 33.0 |
| | 11.30 | | 25 | | sl. yel. | | 1d | | 9.0 | | 33.0 |

Abbreviations—sl., slight; yel., yellow; rd., reddish; pur., purple. v, vegetable; d, disagreeable.

## TABLE NO. 8.

## SUMMARY OF CHEMICAL ANALYSES OF MIXED SAMPLES FROM THE PASSAIC RIVER ABOVE AND BELOW PATERSON.

JUNE 12, 1906.

(Parts per million.)

| Source of Sample | At Bridge above Passaic Falls | At 19th St. Bridge |
|---|---|---|
| Date of Collection | June 12 | June 12 |
| Hour of Collection | 11 a. m. to 9 p. m. | 6.20 a. m. to 11.30 p.m |
| Physical Analysis | | |
| Turbidity | 13 | 25 |
| Color | 34 | Purple Black |
| Odor | 1v | 2d |
| Chemical Analysis (Parts per million) | | |
| Nitrogen as Albuminoid Ammonia | .220 | .640 |
| Nitrogen as Free Ammonia | .050 | .890 |
| Nitrogen as Nitrites | .005 | .003 |
| Nitrogen as Nitrates | .22 | .05 |
| Total Organic Nitrogen | .400 | 1.350 |
| Oxygen consumed | 3.8 | 12.2 |
| Total residue | 79.0 | 134.0 |
| Loss on ignition | 25.0 | 57.0 |
| Fixed residue | 54.0 | 77.0 |
| Suspended solids | 5.0 | 21.0 |
| Iron | .8 | 1.3 |
| Total hardness | 34.0 | 37.5 |
| Alkalinity | 26.0 | 34.0 |
| Incrustants | 8.0 | 3.5 |
| Chlorine | 4.0 | 11.0 |
| Fats | 6.0 | 14 0 |

SEWAGE OF PATERSON, N. J., GAUGINGS

| Date | Hour | Sewer | Flow million gallons per day | Total Solids | | Loss on Ignition | | Suspended | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Parts per Million | Lbs. per day | Parts per Million | Lbs. per day | Parts per Million | Ll |
| East | Bank | | | | | | | | |
| | | West St. | 0.11 | 472 | 3220 | 224 | 1530 | 124 | |
| Apr. 18 | 12.15 P. M. | Main St. | 0.16 | 363 | 485 | 150 | 200 | 45 | |
| | 1.00 | Montgomery St. | | 785 | | 645 | | 140 | |
| | | | 3.00 | 822 | 20000 | 406 | 13100 | 312 | |
| | 1.30 | Straight St. | 0.69 | 710 | 4090 | 290 | 1670 | 145 | |
| | 2.00 | Franklin St. | 0.02 | 1650 | 220 | 625 | 104 | 265 | |
| | 2.25 | Warren St. | 2.08 | 580 | 10100 | 260 | 4510 | 117 | |
| Apr. 19 | 3.15 | Auger & Simon's East 5th St. | 4.06 | 825 | 28000 | 537 | 18000 | 358 | 1 |
| | 2.50 | East 11th St. | 0.09 | 620 | 465 | 437 | 329 | 164 | |
| | 2.30 | 4th Ave. | 0.19 | 456 | 725 | 300 | 476 | 178 | |
| | 2.00 | 2nd Ave. | 0.05 | 392 | 163 | 214 | 89 | 125 | |
| | 1.30 | 3rd Ave. | 0.32 | 416 | 1108 | 193 | 515 | 84 | |
| | 12.30 | 33rd St. | | 617 | | 392 | | 88 | |
| | | | 2.01 | 429 | 6700 | 254 | 4360 | 120 | |
| | 11.15 A. M. | Market St. | 7.35 | 429 | 26300 | 187 | 114300 | 74 | |
| West | Bank | | | | | | | | |
| Apr. 18 | 5.00 | N. West St. | 2.75 | 645 | 14800 | 310 | 7100 | 59 | |
| | 4.20 | N. Main St. | 0.13 | 440 | 477 | 231 | 250 | 136 | |
| | | Arch St. | 0.20 | 555 | 925 | 223 | 371 | 124 | |
| | | Jefferson St. | 0.30 | 2755 | 6860 | 1866 | 4670 | 641 | |
| | | Total excluding East 5th St. Sewer | 19.45 | | 96638 | | 50704 | | 1 |
| | | Estimated Number of Pounds per day, 16 Sewers | | | 74140 | | 39000 | | 1 |
| | | Estimated Number of Pounds per day, Entire City | | | 87200 | | 45900 | | 1 |
| | | Estimated Number of Grams per Capita Daily | | | 360 | | 189 | | |

## ND ANALYSES MADE APRIL 18-20, 1906.

| lids | Chlorine | | Free Ammonia | | Alb. Am. Total | | Alb. Am. in Suspension | | Fats | |
|---|---|---|---|---|---|---|---|---|---|---|
| per ay | Parts per Million | Lbs. per day | Parts per Million | Lbs. per day | Parts per Million | Lbs. per day | Parts per Million | Lbs. per day | Parts per Million | Lbs. per day |
| 845 | 30 | 22 | 12.8 | 8.2 | 4.40 | 3.0 | 1 50 | 1.1 | 67 | 458 |
| 60 | 80 | 107 | 18.7 | 2.5 | 3.70 | 4.9 | 1.50 | 2.0 | 260 | 347 |
| | 100 | | 15.8 | | 5.00 | | 1.70 | | 271 | |
| 630 | 65 | 2050 | 26.9 | 532 | 9.80 | 184.5 | 3.20 | 61.0 | 110 | 4740 |
| 835 | 40 | 231 | 18.2 | 104 | 7.60 | 43.7 | 2.30 | 13.3 | 75 | 432 |
| 44 | 225 | 38 | 23.2 | 4 | 7.00 | 1.2 | 3 20 | 0.5 | 284 | 47 |
| 030 | 40 | 694 | 18.0 | 309 | 3.60 | 62.5 | 1.40 | 22.5 | 115 | 1940 |
| 300 | 25 | 847 | 4.10 | 139 | 3.90 | 132.0 | 1 20 | 74 8 | 92 | 3120 |
| 123 | 45 | 34 | 45 0 | 34 | 9.90 | 7.4 | 2.50 | 1.9 | 180 | 135 |
| 282 | 30 | 48 | 19.1 | 30 | 6.50 | 10.3 | 2.30 | 3.6 | 123 | 195 |
| 53 | 24 | 10 | 14.0 | 6 | 3.60 | 1.5 | 0.40 | 0.2 | 80 | 33 |
| 234 | 65 | 173 | 20.2 | 54 | 3 40 | 9 1 | 1.00 | 2.7 | 55 | 147 |
| | 140 | | 21.6 | | 5.50 | | 1.90 | | 110 | |
| 090 | 50 | 1440 | 22.5 | 254 | 4.60 | 62.0 | 0.60 | 19.2 | 201 | 1475 |
| 550 | 23 | 1410 | 9.10 | 560 | 2.10 | 128 5 | 0.90 | 55.0 | 47 | 2880 |
| 350 | 55 | 1260 | 6.5 | 149 | 4.70 | 108 | 1.30 | 29.9 | 125 | 3090 |
| 147 | 30 | 33 | 20 8 | 23 | 3.70 | 4.0 | 1.00 | 1.1 | 85 | 95 |
| 206 | 50 | 83 | 18.2 | 31 | 4.20 | 7.0 | 0.50 | 0.8 | 105 | 175 |
| 00 | 65 | 163 | 12.4 | 31 | 9.90 | 25.0 | 3.90 | 9.7 | 256 | 640 |
| 59 | | 7796 | | 1542 | | 662.6 | | 224.5 | | 16879 |
| .50 | | 6000 | | 1190 | | 510 | | 173.0 | | 13000 |
| 50 | | 7060 | | 1400 | | 600 | | 204.0 | | 15300 |
| 69 | | 29 | | 5.8 | | 2.5 | | 0.8 | | 63 |

UNIV. OF MICH.

### APPENDIX NO. II

# SEWAGE DISPOSAL IN ENGLAND.

### By George C. Whipple.

**Introduction.** During the last few years the advance made in the art of sewage disposal has been conspicuous and most gratifying. It has been due not so much to the introduction of new methods of treatment as to a thorough trying out of methods already known. Theories recently advanced have been put to practical test, and the published reports of successes and failures have helped much to establish in the minds of engineers clearer conceptions of the general principles involved. Through the midst of confused notions about septic tanks, contact beds and trickling filters, primary systems and secondary beds, and through the haze of bacteriological mysteries surrounding aerobic and anaerobic processes, experience and common sense are forcing their way and developing rational and practical methods of treatment. Of the new ideas some have been already cast aside as unsatisfactory, impractical or too expensive, while others seem likely to sink into innocuous desuetude before many years. A few, however, have proved of such substantial benefit that they justify all the expenditure of time and money which has been given to the study of the subject by many investigators working in many lands.

England has taken the lead in these matters and it is there that one must go to find the latest developments in the art of sewage disposal. If one asks the reason for this, a fitting reply is found in the old adage that "necessity is the mother of invention." The English rivers are small, the English cities are large and numerous, and the amount of manufacturing carried on in them is very great; consequently the streams are badly polluted and the need of sewage purification works is pressing. Furthermore, the soil of the country is not well suited for land treatment of sewage, and in consequence the English engineers have been forced to adopt other methods. This has stimulated their ingenuity and given rise to many modifications of chemical and bacterial processes. In England, therefore, one can see more and learn more of sewage disposal at the present time than anywhere else in the world.

French and German sanitarians have not been idle, however, and the experimental work now being carried on is sure to be followed by the construction of important works suited to their local needs.

In America the theory of sewage purification processes has been assiduously studied at a number of testing stations, notably at the Lawrence Experiment Station of the Massachusetts State Board of Health, at Columbus, Ohio, and at the Massachusetts Institute of Technology. For the most part the results of these studies agree with those made in England at Manchester, Birmington, Leeds, Bradford, and elsewhere. Few important sewage disposal works have been put in operation in the United States during recent years; in fact, except at Worcester, Mass., and at Providence, R. I., there are no sewage purification works of the first rank in this country. But a large plant is under construction at Columbus, Ohio, and a large project is being considered for Baltimore, Md., while many small plants have been built and are in operation.

**Visit to England.**

In order to obtain the latest ideas in the art of sewage purification and to obtain first-hand information as to the practical operation of some of the newer methods of disposal, Mr. Henry J. Hewat, Member of the Joint Committee on Sewage Disposal, and I made a trip to England in March and April of the present year. We spent about three weeks in England together, after which Mr. Hewat went to Ireland, while I went to Belgium and France.

We arrived in England on March 11th, and went at once to London. There we came in contact with the leading consulting engineers and chemists, as well as the officials in charge of the water supply and sewerage of the City of London. Through the courtesy of Mr. M. Fitzmaurice, Chief Engineer of the London County Council, and Dr. Frank Clowes, the chemist, we were taken down the river Thames in a launch to see the chemical precipitation plant at Barking. From London we made a side trip to Hampton, where we saw a septic tank of novel construction, designed by Dr. W. Owen Travis. Mr. Thomas Hughes, the manager, showed us over the works.

After spending several days in the metropolis we went to Scotland and visited Castle Douglas, the early home of Mr. Hewat, Glasgow and Edinburgh. At Glasgow we were entertained by Mr. James Barr, Consulting Engineer, and at Edinburgh by Dr. Fred Dittmar, Sanitary Inspector.

From Edinburgh we went to Manchester, the center of the manufacturing district of middle England. There we remained several days and had opportunities not only of seeing the Manchester works, but the neighboring works at Salford, Hyde, Macclesfield and Rochdale. We also had profitable interviews with Mr. R,

A. Tatton and Dr. Frank Scudder, chief inspector and chemist, respectively, of the Mersey-Irwell Joint Committee. We had interviews with the engineers of the Manchester Ship Canal and with Mr. Meade, the city engineer. At the Manchester sewage works we were entertained by Dr. Edward Ardern, the chemist in charge, and Mr. James P. Wilkinson, the engineer of the Rivers Board; at Salford by Mr. Joseph Corbett, the chief engineer; at Hyde by Thomas Horrocks, the manager of the works; at Macclesfield by Mr. T. Davis, manager; and at Rochdale by Henry Ledson, manager of the works.

We spent Sunday in old Chester and visited the sewage plant in the afternoon. Mr. Thomas Fleet showed us around.

The next day we went to Preston and called on Mr. Edward Halliwell, the chief inspector of the Ribble Joint Committee. He sent one of his assistants with us in the afternoon to Darwen and Burnley. At Darwen we were entertained by Mr. R. W. Smith-Saville, the Borough Engineer, and at Burnley by Mr. G. H. Pickles and Mr. Raymond Ross, the engineer and chemist, respectively, of the sewage works.

The next day we visited Bradford in the forenoon and Leeds in the afternoon. At Bradford we were shown around the works by Mr. Joseph Garfield, engineer in charge, and at Leeds we were received by Mr. W. H. Harrison, the chemist, who has had charge of the experiment station for some years.

Going to Wakefield the next day, we had a long interview with Dr. H. MacLean Wilson, the chief inspector of the West Riding Rivers Board, after which we visited some of the manufacturing establishments in the vicinity to see how their trade wastes are treated. From Wakefield we went to Birmingham, where we spent the entire day at the sewage works. Mr. John D. Watson, the chief engineer, gave us several hours of his time in the forenoon, and assigned one of his assistants to be with us for the rest of the day.

My next visit was to Stafford, where I met Dr. George Reid, the County Medical Officer for Staffordshire, who is in charge of the sewage disposal works in that county. In the afternoon I went to Stoke, the place where the Wedgewood china is made, and saw the Hanley sewage works.

During his visit to Ireland, Mr. Hewat went to Lisbon, Belfast, and Newcastle. At Belfast he was kindly received by Dr. E. A. Letts, the Professor of Chemistry in Queens College.

My visit to the continent related more to water works projects than to sewage disposal, but incidentally I accumulated data in regard to what is being done in Germany, Belgium, Holland and

France. Time did not permit me to visit many sewage works, and my information was derived chiefly from printed reports and from conversations with city officials.

Our last day in England was spent together at Liverpool, where we discussed the subject of sewage disposal with the city engineer, Mr. J. A. Brodie, and Mr. Joseph Parry, the Water Engineer. Altogether we visited over twenty typical sewage works in England and had interviews with between seventy and eighty engineers and chemists.

Among the consulting engineers and chemists to whom we were under obligations for special favors the following should be mentioned:

Dr. Samuel Rideal, Consulting Chemist, London; Mr. W. J. Dibdin, Consulting Chemist, London; Mr. A. J. Martin, Consulting Engineer, London; Mr. J. H. Tudsbury, Secretary Institute C. E.; Mr. H. H. Hellins, Resident Engineer, Dublin Sewage Works; William B. Bryan, Chief Engineer, Metropolitan Water Board; Dr. A. C. Houston, Chemist, Metropolitan Water Board; Dr. G. W. McGowan, Chemist to Royal Committee on Sewage Disposal; Mr. Willcocks, Chief Engineering Inspector, Local Government Board; Mr. Frederick J. Willis, Secretary to Royal Commission on Sewage Disposal; Dr. William H. Power, Member of Local Government Board; Dr. John C. Thresh, Consulting Chemist, London; and Dr. Henry Robinson, Consulting Engineer, London.

To all of the gentlemen above named we wish to express our thanks for their many kindnesses.

**Pollution of Streams.** In order to fully understand the serious conditions which are met with in England regarding the pollution of inland streams it is necessary to compare the density of the populations in certain regions of England with those which exist in the United States, and especially at Paterson.

England has a total population of 30,800,000 and an area of 50,867 square miles. The population per square mile is therefore 606. The central part of England is very much more densely populated than this, as will be seen from the following figures for three of the inland counties:

| County | Population. | Area in square miles. | Population per square mile. |
|---|---|---|---|
| Lancashire | 4,437,500 | 2,030 | 2,190 |
| Yorkshire (West Riding) | 2,750,500 | 2,770 | 1,000 |
| Staffordshire | 1,237,000 | 1,265 | 980 |

If these figures are compared with some of the American states the results will be striking.

| State. | Population. | Area in square miles. | Population per square mile. |
|---|---|---|---|
| Massachusetts | 2,420,982 | 8,315 | 291 |
| Rhode Island | 428,556 | 1,250 | 343 |
| Connecticut | 908,355 | 4,990 | 182 |
| New York | 7,268,012 | 49,170 | 148 |
| New Jersey | 1,883,669 | 7,815 | 241 |
| Pennsylvania | 6,302,115 | 45,215 | 139 |
| Delaware | 184,735 | 2,050 | 90 |

Another way of comparing English and American conditions is to consider the number of cities of different size as given in the following comparison of the two countries.

| Population. | England. | America. |
|---|---|---|
| 1,000,000 or over | 1 | 3 |
| 500,000 to 1,000,000 | 13 | 16 |
| 120,000 to 500,000 | 19 | 19 |
| 50,000 to 100,000 | 41 | 40 |
| Total | 74 | 78 |

It will be seen from these figures that there are nearly as many cities of more than 50,000 inhabitants in England as there are in America, while the United States has nearly seventy-five times as much territory as England.

Figures have been compiled for the West Riding of Yorkshire showing the drainage area, populations and pollution statistics of various streams included within the jurisdiction of the West Riding joint committee. These figures, which are given below, show that the river Aire has a population density of 2,380 per square mile. This river drains a great manufacturing district, including the cities of Bradford and Leeds. The pollution of the stream by the trade wastes is even greater than that due to domestic sewage. With this fact in mind, and remembering also that the rainfall in England is but little more than one-half that in New Jersey, it will be seen how much more difficult a problem exists in the middle district of England than in the region around New York.

TABLE SHOWING THE DRAINAGE AREAS, POPULATIONS AND POLLUTION STATISTICS FOR THE WEST RIDING OF YORKSHIRE, ENGLAND.

| River. | Drainage area in sq.miles. | Population. | Population per sq. mile. | Number of sewage works. | Number of direct trade pollutions. |
|---|---|---|---|---|---|
| Aire | 422 | 1,001,000 | 2,380 | 72 | 230 |
| Dalder | 368 | 701,000 | 1,905 | 70 | 602 |
| Don | 537 | 795,000 | 1,480 | 97 | 140 |
| Lune | 169 | 10,000 | 59 | 8 | 7 |
| Ouse, (including Wharfe, Nidd and Ure) | 877 | 173,000 | 197 | 39 | 54 |
| Tame | 28 | 17,000 | 608 | 4 | 36 |
| Trent | 162 | 34,000 | 210 | 8 | 2 |
| Ribble | 230 | 19,000 | 83 | 7 | 9 |
| Totals | 2,793 | 2,750,000 | — | 305 | 1,080 |
| Average | — | — | 986 | — | — |

Some of the streams which drain into the Mersey river in the west of England are even more highly populated than those which flow in an easterly direction. Thus the watersheds of the Irwell and the Manchester Ship Canal, which receive the sewage of Manchester, Salford, and other large cities, have a drainage area of 312 square miles, a population of 1,105,000 and a population density of 3,540 per square mile. If certain smaller streams were considered, population densities considerably greater than the above would be found. The Mersey-Irwell Joint Committee has within its jurisdiction 117 separate sewage disposal works and 453 trade wastes discharges. The Ribble Board has under its jurisdiction 63 sewage works and 66 trade wastes discharges.

Altogether in the middle of England there are upwards of 400 sewage works and several thousand instances of stream pollution by liquid wastes from manufacturing establishments.

The drainage area of the Passaic river above the Dundee Dam is 822 square miles, while the total population in 1900, including Paterson, amounted to about 194,000, or 235 per square mile. The drainage area of the entire stream is 949 square miles, and the total population about 575,000, or about 600 per square mile. It will be seen therefore that the Passaic river is less polluted than the streams in the middle districts of England.

**Legislation.** English legislation regarding the pollution of streams is based on the Public Health Act of 1875 and the Rivers Pollution Prevention Act of 1876. Both of these are general acts which apply to Scotland and Ireland as well as to England and Wales. In 1892 a special act was passed establishing a Joint Committee for the Mersey and Irwell watersheds, and in 1894 a similar Act was passed creating a similar authority for the West Riding of Yorkshire. As these acts stand as the basis of the work which is now being done in England to protect the inland streams from sewage pollution, and as these acts are not well known in this country, the following quotations from the Mersey and Irwell Joint Committee Act of 1892 are here given:

1. This Act may be cited as "The Mersey and Irwell Joint Committee Act, 1892."

PART I.-SOLID MATTERS.

2. Every person who—

(a) Puts or throws, or causes to be put or thrown, or to fall ; or

(b) Knowingly permits to be put or to fall or to be carried ; or

(c) Causes or knowingly permits to be put in such a position as to be liable to fall or to be carried into any river or stream within the jurisdiction of the Joint Committee the solid refuse of any manufactory, manufacturing process, brickyard, mine, pitshaft, or quarry, or any ashes, cinders, or clinkers, or any building rubbish, or any sludge, or any solid sewage matter, shall be deemed to have committed an offence against this Act.

PART II.—LIQUID SEWAGE POLLUTION.

3. Every person who causes to fall or flow, or knowingly permits to fall or flow or to be carried into any river or stream within the jurisdiction of the Joint Committee, any liquid sewage matter shall (subject as in this Act mentioned) be deemed to have committed an offence against this Act.

4. On the application of any sanitary authority who at the passing of this act is committing any offence within the meaning of the last preceding section, the Joint Committee may, if having regard to all the circumstances of the case they think necessary, by order grant time to prevent the commission of the offence, and during the time specified in the order (which may be extended by a subsequent order), no proceedings under the said section shall be taken by the Joint Committee against the authority named in the order.

PART III.—LIQUID MANUFACTURING POLLUTION.

5. (1) Every person who causes to fall or flow or knowingly permits to fall or flow or to be carried into any river or stream within the jurisdiction of the Joint Committee any poisonous, noxious, or polluting liquid which proceeds from any manufactory or manufacturing process shall (subject as in this Act mentioned) be deemed to have committed an offence against this Act.

(2) Where any such poisonous, noxious, or polluting liquid as aforesaid falls or flows or is carried into any river or stream along a channel used, constructed, or in process of construction at the date of the passing of the Rivers Pollution Prevention act, 1876, or any new channel, constructed in substitution thereof, and having its outfall at

the same spot for the purpose of conveying such liquid, the person causing or knowingly permitting the poisonous, noxious, or polluting liquid so to fall or flow or to be carried, shall not be deemed to have committed an offence against this Act if he shows to the satisfaction of the court having cognizance of the case that he is using the best practicable and reasonably available means to render harmless the poisonous, noxious, or polluting liquid so falling or flowing or carried into the river or stream.

6. (1) Proceedings shall not be taken under this part of this Act against any person without the consent of the Local Government Board.

(2) The Joint Committee shall, one month at least before taking proceedings under this part of this Act against any person, serve, by post or otherwise, on such person a written notice inviting him, if he desires to show cause why proceedings should not be taken, to appear before the Joint Committee at a time and place to be specified in the notice.

(3) If the Joint Committee, either after hearing such person, or in default of his appearance, decide that proceedings ought to be taken, they shall forthwith notify their decision, and the grounds thereof, to such person, and to the Local Government Board, and shall apply for the Board's consent.

(4) The Board may hold a local inquiry into the circumstances of the case, but shall inform the Joint Committee and such person whether they give or withhold their consent before the expiration of three months from the date of the Joint Committee's application for it.

(5) The Joint Committee shall not take proceedings against any person under this part of this Act, and the Local Government Board shall not give their consent to such proceedings, unless the Joint Committee and the Board respectively are satisfied that means for rendering harmless the poisonous, noxious or polluting liquid are reasonably practicable and available under all the circumstances of the case.

## PART IV.—PENALTIES AND PROCEDURE.

7. Every person who commits an offense against this Act for which no other penalty is specified, shall be liable, for the first offence, to a penalty not exceeding twenty pounds, and for a second or any subsequent offence, to a penalty not exceeding fifty pounds, and to a penalty not exceeding forty shillings for every day on which the offence is continued after conviction.

8. (1.) Offences under this act may be prosecuted and penalties recovered in a summary manner before a court of summary jurisdiction by the Joint Committee, or by the clerk or other officer of the Joint Committee authorized in that behalf.

(2.) All penalties recovered under this act shall be carried to the credit of the common fund of the Joint Committee.

(3.) A court of summary jurisdiction before which any person is summoned for an offence under this Act may, by order, require such person to abstain from the commission of such offence, and where such offence consists in default to perform a duty under this Act, may require him to perform such duty in manner in the said order specified. The court may insert in any order such conditions as to time or mode of action as it may think just, and may suspend or rescind any order on such undertaking being given or condition being performed as it may think just, and generally may give such directions for carrying into effect any order as to the court seems meet.

(4.) Any person making default in complying with any requirement of an order of the Court under this section shall be liable to a penalty not exceeding fifty pounds a day for every day during which he is in default, as the Court may order.

9. If either party in any proceedings feels aggrieved by the decision of a court of summary jurisdiction under this Act, such party may appeal to the next practicable Court of Quarter Sessions holden in or for the county, borough or place where the matter of appeal arises.

10. For the better enforcement of the provisions of this Act, it shall be lawful for any officer of or other person authorized by the Joint Committee, at any time to enter on any lands, manufactory, or other work or building, for the purpose of taking and carrying away and to take and carry away, samples of any effluent at the point where it passes into any river or stream within the jurisdiction of the Joint Committee. Such officer or person shall leave under seal a duplicate of every sample taken by him with the owner or occupier of the premises whence the effluent flows.

Any person who obstructs or molests any such officer or other person shall be liable to a penalty not exceeding five pounds.

11. All the powers and provisions of this Act are in addition to and not in derogation of, any other powers possessed by the Joint Committee under the provisions of the Local Government Board's Provisional Orders Confirmation (No. 10) Act, 1891, and the Joint Committee may exercise all or any of such other powers as if this Act had not been passed:

Nothing in this Act shall prejudice or in any way affect or curtail the right of any sanitary authority, or of any conservators or other public body, or of any individual, to continue or to commence proceedings against any person or body of persons in respect of any pollution of the rivers Mersey or Irwell, or any tributary thereof respectively:

Provided that (save as hereinafter mentioned) proceedings shall not be taken against any person under this Act while proceedings are pending against such person in respect of the same or a similar offence under any other Act, and proceedings shall not be taken against any person under any other Act while proceedings are pending against such person in respect of the same offence under this Act.

Nevertheless, if in any case the Local Government Board shall be of opinion, on the representation of the Joint Committee or of any other person, that any proceedings pending under this Act, or any other Act, are not being prosecuted bona fide and with due diligence, they may by order authorize such other proceedings to be taken, either under this Act or under any other Act, and either by the Joint Committee or by any personas, having regard to all the circumstances of the case, the Board may think just.

12. The Local Government Board may make orders as to the costs incurred by them in relation to inquiries instituted by them under this Act, and as to the parties by whom such costs shall be borne, and every such order, and every order for the payment of costs made by the said board under this Act may be made a rule of the High Court.

13. Inspectors of the Local Government Board shall, for the purposes of any inquiry directed by the Board under this Act, have, in relation to witnesses and their examination, the production of papers and accounts, and the inspection of places and matters required to be inspected, similar powers to those which the inspectors of the said Board have under the Public Health Act, 1875, for the purposes of that Act."

**Increase in Sewage Disposal Works.**

The effect of the special acts of 1892 and 1894 is strikingly shown by the following figures taken from the annual report of the West Riding Rivers for 1904. It will be seen that there has been a constant increase in the number of sewage purification works. In 1892 out of ninety authorities only 35 per cent. had sewage works in operation; in 1904, 95 per cent. of them had purification works.

### TABLE SHOWING THE INCREASE IN THE NUMBER OF SEWAGE DISPOSAL PLANTS IN THE WEST RIDING OF YORKSHIRE, FROM 1892 TO 1904.

(From the Annual Report of the Rivers Board for 1904.)

| Year. | Works in operation. | Works being constructed and operated. | Works in operation or under construction or which have had schemes sanctioned. | Works in operation or under construction or which have had scheme submitted or bill offered. | Total. number of authorities. |
|---|---|---|---|---|---|
| 1892 | 32 | 40 | 42 | 48 | 90 |
| 1893 | 34 | 41 | 49 | 71 | 90 |
| 1894 | 39 | 59 | 62 | 76 | 90 |
| 1895 | 43 | 72 | 76 | 82 | 90 |
| 1896 | 55 | 82 | 84 | 84 | 90 |
| 1897 | 62 | 82 | 84 | 85 | 90 |
| 1898 | 68 | 83 | 85 | 86 | 90 |
| 1899 | 75 | 84 | 84 | 85 | 90 |
| 1900 | 81 | 86 | 87 | 87 | 90 |
| 1901 | 80 | 86 | 86 | 86 | 90 |
| 1902 | 82 | 85 | 85 | 86 | 90 |
| 1903 | 85 | 85 | 85 | 86 | 90 |
| 1904 | 85 | 85 | 85 | 85 | 90 |

Testimony which has been given before the Royal Commission and elsewhere indicates that the improvement in the quality of the water in the rivers since these works were established has been very noticeable. In some cases streams which were foul and stinking have become stocked with fish. In other cases, however, the purification of sewage and the removal of trade wastes has scarcely kept pace with the increasing population.

In spite of the generally excellent results which have been obtained under the operation of the above mentioned laws, English sanitarians are of the opinion that further legislation is necessary in order that the work of streams protection may be fully consummated. What appears to be needed in England is a central rivers authority, with controlling powers over individuals as well as over local authorities. This was recommended by the Royal Commission on Sewage Disposal in 1903, and is likely to be taken up by Parliament at an early date. The Local Government Board of England already exercises a certain general authority over the local authorities with respect to methods of sewage disposal. No government grants of money can be made until the plans of the contemplated works have been approved by the Local Government Board. This Board, however, does not have sufficient authority over the individual manufacturers and their relations with local governments, and it is to the correction of this condition that future legislation will be in part directed. Unquestionably the legislation which has been proposed would be highly beneficial to the sanitary interests of the kingdom.

There is at the present time in England a Royal Commission on Sewage Disposal. Since its establishment in 1898 several interim reports have been issued, and it is said that the main report, though perhaps not the final one, will be published during the coming summer. This report will contain a vast amount of data on the construction and operation of the sewage works in England, and its publication will be looked forward to with much interest by sanitarians all over the world.

**Manufacturing Wastes.** The question of what to do with manufacturing wastes is one which is receiving no little attention at the hands of English authorities at the present time, and is one of the main reasons for desiring the establishment of a central authority controlling pollution of streams. Whether manufacturing wastes should be allowed free admission to sewers, whether they should be admitted after partial clarification, or whether they should be purified and discharged directly into the streams, are methods which have their ardent advocates. At the present time there is no regularity in the matter. For example, in the West Riding district twenty-five authorities refuse to admit trade effluents to the sewers, four admit them subject to certain conditions, and sixteen admit them unconditionally. This differential treatment is, in some instances, bitterly complained of by manufacturers as being unjust.

Whether manufacturers should be obliged to purify their liquid wastes to a greater or less extent, and whether or not local authorities should be obliged to construct sewers of sufficient capacity to take trade effluents, are matters which are much discussed. One of the sections of the Rivers Pollution Prevention Act of 1876 provided that local authorities might refuse to allow trade effluents to enter sewers on any of the following reasons:—

(1) That they would injure the sewer, (2) that they would prejudicially affect the disposal of the sewage, (3) that their volume

was too great for the capacity of the sewer, and (4) that their admission to the sewer would interfere with some order of a court of competent jurisdiction. While this law is apparently precise, it has been found uncertain in many particular cases and has resulted in the lack of enforcement, in the postponement of sewage purification works, and in numerous conflicts between manufacturers and local authorities.

As to whether or not trade wastes should be discharged into sewers rather than be purified and allowed to flow directly into streams, opinion seems to be crystallizing in favor of the former method. Nearly all of the inspectors of the rivers boards informed us that separate purification works were generally expensive to the manufacturers and inefficient in operation. They were clearly of the opinion that in order that the waters of the streams should be made pure it would be necessary to take the trade wastes out of the rivers except in the case of those where the character of the liquid discharged was not of a polluting character. Upon the questions as to whether trade wastes should have free access to the sewers, whether they should be partially clarified and so stored that they could be delivered into the sewers at a regular and constant rate, or whether they should be admitted to the sewers with little or no treatment and the manufacturers charged an extra fee for the privilege of entry according to the quality of the liquid, are matters still in dispute.

From the evidence taken by the Royal Committee on Sewage Disposal it was said that the cost of purifying trade wastes after mixture with the city sewage is less than the cost of their separate purification at the individual works; that manufacturers ought to remove the bulk of the solids in suspension from their effluents and neutralize the liquid, if strongly acid, before allowing it to enter the sewers; that it should be the duty of local authorities to provide such sewers as are necessary to carry trade effluents as well as domestic sewage; and that, as far as practicable, no special charge should be laid on the manufacturer on account of the character of the trade waste. It was recognized, however, that in exceptional cases, where wastes particularly difficult to purify are discharged into the sewage, a special charge is just. In case the manufacturer is unable to agree with local authorities as to the fairness of such charge the amount should be settled by a central authority.

In Bradford and Brighouse, where the general policy has been adopted of receiving trade effluents into the sewers and prohibiting them from being discharged into the streams, a special charge is made on the manufacturers according to the quality of the wastes.

We learned that in Bradford this varied from 2c. to 15c. per thousand gallons. Brighouse is the local centre of the silk industry of Yorkshire. Here the authorities charge 8c. per thousand gallons for silk suds and 4c. per thousand gallons for dye stuffs. Asking for the method by which the amount of these charges was established we were told that the apportionment is made by estimating the cost of sewage works for the domestic sewage of the city alone, and then for works capable of treating the domestic sewage plus the trade wastes. The difference in cost is divided among the manufacturers according to the character and amount of the effluent which they put into the sewers, and a charge is made of so much per thousand gallons. A constant stipulation in this case is that the waste shall be delivered into the sewers at a constant rate which, of course, requires a certain amount of storage at the works. In this connection it may be remarked that one of the characteristic features of manufacturing establishments in England, as seen from the trains, is the inevitable settling basin.

Dr. H. MacLean Wilson, chief inspector of the West Riding Rivers Board, has studied the treatment of silk wastes in individual plants to some extent. He told us that thus far individual treatment of these wastes has not been successful. He believes that in general better and cheaper results would follow by allowing each manufacturer to discharge his effluent into the sewers after partial clarification.

Further data on the subject of trade effluents is given in the third report of the Royal Commission on Sewage Disposal, published in 1903.

## METHODS OF SEWAGE DISPOSAL.

One of the signs of advancement in the art of sewage disposal is the general recognition of the fact that an economical process of purification must proceed by distinct stages. This has resulted in the classification of processes into certain groups, the separation of which will add much to a clear insight of the subject.

The processes involved in sewage purification may be divided into three principal groups, namely:

1. Preparatory Processes,
2. Purification Processes,
3. Finishing Processes.

In one sense these are all purification processes, as they all tend to make the liquid sewage less offensive. Each group has many subdivisions as shown below, and the various methods are used in all sorts of combinations, as may be seen from the table given below showing the processes used at the works which Mr. Hewat and I visited. The variations are chiefly for adapting the treatment to local conditions, but too often they are due to idiosyncrasies of the designing engineers or to the pernicious activities of companies owning certain patent rights.

## CLASSIFICATION OF METHODS.

| Preparatory Processes. | Purification Processes. | Finishing Processes. |
|---|---|---|
| Screens, | Sub-surface Irrigation, | For Clarification. |
| Roughing Filters, | Broad Irrigation, | Settling Basins, |
| Plain Settling Tanks, | Intermittent Filtration, | Coarse Filtration. |
| Detritus tanks, | Contact Beds, | For Bacterial Improvement. |
| Chemical Precipitation Tanks, | Sprinkling Filters. | Land Treatment. |
| Septic Tanks. | | Sand Filtration, |
| | | Mechanical Filtration, |
| | | Disinfection. |

In sewage purification there is a gradual separation of the solid matter from the liquid; the sludge is ultimately disposed of in one way and the more or less purified liquid sewage in another. Thus, two more general groups must be provided for convenience of discussion, namely,

4. Disposal of Sludge,
5. Disposal of Purified Effluent.

To those may be added a sixth, namely,

6. Disposal of Storm Water.

## PREPARATORY PROCESSES.

Raw sewage cannot be economically purified by the direct application of any single process. This is on account of the complex character of its constituents. A liquid which contains substances both organic and inorganic, in which a part of each is in solution and another part in suspension, and in which the suspended particles vary in size from banana skins down to the ultra microscopic, a liquid which is continually altering in composition and in decomposition as well, and a liquid continually varying not only in quality but in quantity, cannot be easily rendered free of its obnoxious ingredients.

Some form of preliminary treatment is therefore universally used. This may be a mere screening or filtering out of the coarse suspended matter, or it may be a settling out of the heavier particles in esidmentation tanks through the influence of gravity. Chemical or even biological agencies may be made to assist the action, but essentially all the preparatory processes are of a physical character. They have for their object the removal of suspended matter in order that the remaining liquid may be more easily purified by subsequent treatment.

**Screening.** Little need be said about screening, except that in large plants the use of revolving inclined screens with automatic cleaning devices has rendered this initial step in the process more effective than the old fashiond bar-screens, or cage-screens, which were lifted and cleaned by hand. At Birmingham there is an inclined revolving screen which is operated by an undershot water-wheel placed in the channel conveying the sewage. It works under a six-inch head, the flow being about 3 million gallons a day. The accumulations on this screen, which has a mesh of ¼ inch, are dropped in a gutter, where an endless screw pushes them to one end and deposits them in a cart. Engineers appear to be taking a new interest in the matter of screening; finer and more efficient screens are being advocated, and in the near future important developments may be looked for. In many places the screened material is burnt under boilers, mixed with coal or in some cases with the city garbage, and the power generated is used in various ways around the works. This is the case at Hyde and some other places. At Manchester the screened material is burnt, but the heat is not utilized. At Glasgow they sell the screen sludge for about twenty-five cents per ton.

**Roughing Filters.** Roughing filters are used but little, although they have been studied experimentally in a number of places. As a means of removing suspended matter they are far less economial and much more troublesome than settling tanks. Where they have been used it has generally been in connection with other forms of preparatory treatment. At Salford, for instance, where in the opinion of the engineer they form an essential part of the preparatory process, they are placed between the chemical precipitation tanks and the sprinkling filters.

These scrubbers are composed of gravel screened between $\frac{3}{16}$ inch and ¾-inch sieves. There are six beds each 100 feet long, 30 feet wide and 3 feet deep, underdrained with tiles. It is the intention of the engineer to subdivide these beds and put in a system of washing with air and water so as to make it something like the mechanical filters used for purifying water. The roughing filters at Salford have been cleaned only twice in five years. At the time of our visit, however, we found them so clogged that the engineer did not dare to apply the effluent to the sprinkling filters. One of them was being cleaned.

**Detritus Tanks.** The use of grit chambers, or catch pits, or detritus tanks, or roughing tanks, or settling tanks at high velocities, as they are variously called, is very common. Their usefulness depends largely upon the character of the raw sewage. When the amount of suspended mineral matter is large, as it often is in cities sewered on the combined system, or in places where the amount of manufacturing waste is large, detritus tanks so arranged that they may be easily cleaned without interrupting the flow of sewage are advantageous. They are also helpful in small plants where septic tanks are used. Under certain conditions, where the screening process is efficient and where sedimentation takes place in a manner to be described, the detritus tank may be dispensed with. In England much thought appears to have been given to the design of these detritus tanks. In Glasgow, the sewage, after passing the screens, flows through a long catch-pit of semicircular cross-section, 35 feet wide, 16 feet deep and about 100 feet long. The sludge is removed from this at short intervals by means of an electrically driven bucket dredge. This moves along over the pit on a track, lifts the sludge and conveys it to a car on a parallel track beside the dredge. All this is done, of course, without interrupting the flow of sewage.

The time allowed for settlement in detritus tanks varies all the way from a few minutes to several hours. Often the sewage reaches the works in a septic condition and were it not for frequent cleaning the sludge would undergo septic action which would tend to interfere with the usefulness of the tank for sedimentation at high velocities.

**Plain Sedimentation.** Plain sedimentation at low velocities, unaccompanied by the use of chemicals or by septic action, is but little used in England, although in many settling tanks, if not in most of them, the chemical and biological changes are of secondary importance. In any of the preparatory tank processes the settling of the suspended matter by gravity is the controlling function. Within the last few years there has been a reaction against the too exalted ideas of bacterial agencies as originally set forth, and a recognition of the fact that the separation of sludge from sewage is essentially a physical problem. Plain sedimentation, modified as mentioned beyond, is likely to play an important part in the future.

**Chemical Precipitation.** Twenty-five years ago chemical precipitation was very largely used in England. Lime, or lime and iron, or alum, were considered as necessary accompaniments of the settling process. In many cases this chemical precipitation was the only means of purification used, the tank effluent being discharged directly into river or sea, or turned upon land. The method has to a very great extent been superseded by other modes of treament, but even today there are some large cities near the coast which adhere to the old system, notably London, Glasgow and Dublin, the last named city having new works just about to be put in operation. London has nearly outgrown her works at Barking and Crossness, and although the efficiency of the process is said to be satisfactory, yet the volume of sewage has become so large and the amount of organic matter discharged in the tank effluent is so great that the water of the Thames becomes almost exhausted of its oxygen during the summer when the stream flow diminishes. This is a condition which the authorities recognize will give rise to a nuisance if long continued. In the near future there will be needed some process which will yield a better purified effluent than can be obtained by the use of chemical precipitation alone. On account of the magnitude of her sewage problem London has taken a conservative course and has preferred to adhere to the present method, which is very satisfactory, rather than to embark upon some scheme which has not been tested by experience. This seems to have been a wise policy. The early experiments made at Barking, by Dibdin and his successors, showed the efficiency of contact beds as a means of purification, and have had far reaching effects on the general problem, yet in view of later studies and experience it is questionable whether the adoption of this method for treating all of the London sewage would have been the most economical one.

The Thames Conservancy Board and the London County Council, in view of what has already been done, can probably be relied upon to see that the river does not become offensive. Nothing is more surprising to an American engineer familiar with the Chicago river, or the Passaic river, or the Blackstone river, than to find that the

Thames river, flowing through the heart of the largest city of the world, is clean—no offensive odors, no unsightly scum, no litter on the shores. It is an object lesson in the art of inspecting which may well be studied by American officials.

At Glasgow the condition of the Clyde is rather worse than that of the Thames at London. This is due in a measure to the fact that not all of the sewage of the city is purified, but it has already become clear that chemical precipitation alone will prove unequal to the task of keeping the waters of the Clyde permanently clean, and it is somewhat surprising that the new works now under construction should be practically a duplication of the old plant. The present plants appear to be well operated, however, and to be doing all that can be reasonably expected of them.

The use of chemical precipitation as a preparatory process, however, is quite another matter, and instead of going out of use it seems to be gaining favor, especially in those cities where the amount of manufacturing waste is large. In order for contact beds or sprinkling filters to operate satisfactorily and economically the amount of suspended matter must be reduced to a minimum, fats must be kept down and the colloidal substances precipitated as far as possible. In some cases this appears to be more easily accomplished by the use of chemicals than by plain or septic sedimentation. The sewage of Bradford may be taken as an illustration of this, although it is an exceptional case.

Bradford is a great manufacturing city, the centre of the woolen industry. All the trade wastes, after settling, go into the sewers. The sewage is probably the strongest and most difficult to treat of any in England. The total amount of solid matter is about 1800 parts per million, of which 1100 is in suspension. The amount of fats is about 650 parts per million. Bradford's present chemical precipitation works are completely outgrown and extensive studies have been made during the last few years to determine the best mode of treatment. These studies have shown that the sewage cannot be prepared either for treatment on contact beds or on sprinkling filters by plain sedimentation or by septic sedimentation. Even with the septic period prolonged to two or three days the results were unsatisfactory. The use of chemicals here seems absolutely necessary. The chief difficulty in treating the sewage is due to the excessive amounts of fats present. For this reason sulphuric acid has given better results than lime or other chemicals. The acid decomposes the soaps and separates the fats, parts of which rise to the surface where they are skimmed off. The remainder settles with the sludge from which it is ultimately recovered by steam pressing and distillation. This grease recovery process is more extensively carried on at Bradford than anywhere else in England, and is said to be practically self-supporting. Some sludge, instead of being used for grease recovery, is mixed with coal and burnt under the boilers. The plans for the new works are not fully formulated, but it is understood that in general the process will consist of chemical precipitation followed by sprinkling filters.

At Rochdale, also, chemical precipitation is used as a preparatory treatment. Here also the sewage contains wool waste, and sulphuric acid is used during the day-time. Sulphate of alumina is also used. At Hyde they now have septic tanks followed by sprinkling filters, the use of chemicals having been given up. They are contemplating a return to the use of chemicals, however, during the daytime, as a part of the preparatory process.

The use of "alumino ferric" or "ferrozone," both of which are merely crude forms of sulphate of alumina, is exceedingly common in small plants. Thus within the jurisdiction of the Mersey-Irwell Joint Committee there are seventy out of ninety-eight works at which alum, or some other chemical, is used in connection with preparatory sedimentation processes.

Although in few instances have septic tanks been given up for, or been supplemented by, the use of chemicals, engineers and inspectors appear to be coming back to the idea of using precipitants in connection with the preparatory treatment of sewages heavily laden with manufacturing wastes.

**Septic Sedimentation.** The septic tank is still the subject of more or less controversy in England. It still has its enthusiastic advocates and opponents, but present day discussions are tempered with reason and are based more on fact and less on theory than in earlier days. One thing seems certain, the septic tank has earned its right to exist. It has not accomplished all that its originator first claimed; it does not "do away with sludge;" it does not fit the liquid sewage for further purification; it is not without nuisance. But, on the other hand, if it does not entirely eliminate sludge, it reduces its amount, and alters its character; while if it does not help future treatment of the liquid sewage, it at least does not hinder it. Its chief advantage is its effect on the sludge; a disadvantage is the frequent nuisance from odor.

That the septic tank is a nuisance in many places appears to be well established. On this point the opinions of the inspectors and of residents near the works are more to be trusted than those of the sewage works managers, although even they often complain of bad odors. The extent of the nuisance depends altogether upon the local conditions—the character of the sewage, the size of the plant, the period of septicity, the nature of the subsequent purification process, the topography of the surroundings, the weather conditions, etc. It would be unjust to suppose that the septic tank is always and necessarily a nuisance to neighboring residents. Often it is not.

The septic process is an anaerobic or putrefactive one, and putrefaction, of course, involves the formation of odoriferous gases and offensive substances. Whether or not these become a nuisance depends upon their amount and the opportunity which is given them to escape into the atmosphere. Covers for septic tanks, which were part of the original idea, somewhat prevent the spread of bad odors, but covers are not necessary to the efficiency of the process, are expensive and even dangerous on account of the explosive character of some of the gases liberated. Already several fatal accidents have occurred in England. Open septic tanks are often free of nuisance. In winter the septic action is not as vigorous as in summer, and the products of decomposition are less, while in summer the septic tanks are sometimes covered with a firm dense scum, which to a certain extent prevents the gases from diffusing into the atmosphere.

As an illustration of this might mention the case of a small septic tank which we saw at Birmingham, in which grass was growing on the top of the scum. While we were commenting on this and on the entire absence of odor, the manager's dog strolled leisurely out on the tank and crossed to the other side. In fact, it is said, that at Leeds, men have crossed over the septic tanks on the scum.

When the odors do not escape from the tanks at the surface, however, the liquid effluent is likely to be offensive, and if this effluent is sprayed into the air or poured in thin films over a sprinkling filter, full opportunity is given for the liberation of bad odors. In fact it may be said that whatever serious nuisance arises from the septic tank occurs when it is used in connection with a sprinkling filter. Sanitary inspectors and representatives of the local government board and the royal commission on sewage disposal were all emphatic in expressing their ideas as to the amount and frequency of bad odors due to this combination. From conversation with these officials, and from personal observation, the speaker gathered the opinion that, under English conditions, sprinkling filters treating septic sewage cause enough nuisance to substantially depreciate the value of property for residential purposes within a radius of a quarter of a mile from the works in the case of small plants, or almost half a mile from the works in the case of large plants. If the sewage works were situated in a valley down which the prevailing winds blew in summer the nuisance occasionally extended to greater distances. Every plant must be judged for itself, however, and the above estimate has only a very general application. In America, with more dilute sewages, the circles of influence might be less extensive. Meteorological conditions have a very important effect on the transmission of bad odors. On warm, muggy days with a moderate breeze a sewage plant may be a decided nuisance, while during clear, cool weather, it may attract no attention whatever. This fact is too often overlooked by visitors to sewage works.

Trade wastes sometimes tend to increase the disagreeable odors of septic sewage. This is particularly true of brewery and distillery wastes which contain large amounts of organic matter, sulphur compounds, starch, etc. The period of septicity is perhaps even more important. Much is heard of late about over-septicity, and unquestionably, with the strong English sewages, the twenty-four hour period required by the local government board is often too long. With the weaker sewages met with in this country and with septic periods properly adjusted, the bad odors due to the spraying of septic sewage may be somewhat mitigated.

Practical experience with the septic tank has shown that it tends to reduce the amount of sludge. The suspended mineral matter in sewage is, of course, unchanged in the septic tank, although much of it settles through the action of gravity. A large part of the organic matter is also unaffected by the bacterial process, or, at any rate, remains in the tank as organic matter, though perhaps modified in character. Some of the organic matter in suspension, however, is liquefied or gasified—or, to use a common term, is digested. The amount of digested matter may be taken ordinarily as between one-quarter and one-third of the suspended solids, and therefore the amount of sludge is less by that amount. Some engineers believe that a fifteen per cent. saving of sludge is all that can be expected of a septic tank through digestion. Much depends, of course, upon the character of the sewage. Apparently domestic sewage is better adapted to the septic treatment than sewages rich in trade wastes.

Long standing in the septic tank tends to make the sludge more compact. Speaking roughly it may be said to reduce the volume from one-third to one-half. The character of the sludge becomes altered. This was strikingly illustrated to us by

Mr. John D. Watson, the engineer of the Birmingham Sewage Works. By the aid of a long pole he withdrew portions of sludge from a settling tank which had not been cleaned for three years. The former was fibrous, gray in color and had a marked offensive sewage odor, while the latter was black, granular, and almost odorless. Mr. Watson stated that the septic sludge could be spread upon land without offense, while the application of the sludge from the plain settling tank gave rise to very disagreeable odors. To do away with the latter he has been for some time in the habit of pumping his settled sludge into the septic tanks for further treatment.

Granting that the liquid septic effluent has no virtue and may be a nuisance when applied to sprinkling filters, and granting that the use of the septic tank has a beneficial effect on the sludge, a logical improvement would appear to be to so modify the manner of using the septic tank as to maintain the advantage and eliminate the nuisance. This is a matter now being considered by some of the English investigators. The best method of accomplishing it appears to be by the use of plain sedimentation for the sewage and septic treatment for the sludge alone. In other words, the idea is to treat the liquid portions aerobically and the solid portions anaerobically. This is scientifically correct in principle, as the beneficial anaerobic action is concerned with the carbohydrates, which are chiefly in suspension. In no case with which I am familiar has this result been actually accomplished, but in a number of cases the idea has been partially applied. In the case of Birmingham, just mentioned, the sewage passes somewhat rapidly through settling basins, which are cleaned at frequent intervals, most of the liquid sewage being allowed to flow to certain septic tanks, while the sludge is pumped to other septic tanks for further digestion. This takes care of the sludge, but it does not leave the sewage unseptic when it goes to the sprinkling filters.

At Hampton, England, Ault and Travis have devised what is called a hydrolytic tank. This is a tank with an upper and lower compartment. The raw sewage passes laterally through the upper compartment while the sludge, together with a small percentage of the liquid, settles into the lower compartment, where it goes through the septic process. But in this plant also the liquid sewage becomes septic before it is applied to contact beds. In Macclesfield and elsewhere there are tanks for the storage of sludge, where septic action goes on. There seems to be no reason why the separation of the liquid sewage from the sludge may not be made in such a way as to leave it in a stale or non-septic condition, so that it may be applied to sprinkling filters with the least possible nuisance.

**English Opinions of the Septic Tank.** One of the matters to which Mr. Hewat and I gave particular attention was that of nuisances occasioned by the location of sewage works near populous districts. We realized that the season of our visit was not the best one for making observations, as the strongest odors are observed during the warm weather of summer, and especially on those days when the humidity is high and when there is a light breeze to carry the odor in some particular direction. Under the circumstances we felt that a better judgment could be formed from the opinions of inspectors, consulting engineers, and from people residing near sewage works than from any observations that we might ourselves make.

As to the location of sewage works with respect to habitations we found that almost without exception the attempt was made to locate the works at least a quarter of a mile from thickly settled districts. This was true even of the smallest plants. Larger plants were often located at greater distances. Scattered houses were often nearer than a quarter of a mile, and the sewage works managers and their laborers very often lived nearer to the works than the distances mentioned. Most of the managers told us that their works caused no complaint from the dwellers in houses half a mile away, but from scattered conversations with them and with cabmen and people whom we met on the street we learned that, under certain conditions, the odors would be wafted to distances even greater than one-half a mile.

In our own observations we did not find the odors from the sewage works to be as strong as might be expected, although in one or two notable instances, such as Macclesfield and Chester, the odors around the plant were very offensive.

At Hyde we were told that during the summer the odors were so strong that there was talk of returning to the use of chemical precipitation instead of septic sedimentation for the preliminary treatment of their sewage.

As showing the opinions of engineers and chemists regarding the nuisances due to septic tanks the following quotations from my diary are interesting. They also throw light upon their opinions as to the value of the septic tank in general.

A Consulting Chemist:

"I consider septic tanks to be very useful, but less so when trade wastes are present. Most trade wastes affect the quantity more than the quality of the matter in the sewage so far as treatment is concerned. Septic effluents when sprayed into the air, as in the case of a sprinkling filter, are productive of a nuisance."

A Consulting Chemist:

"I am absolutely opposed to septic tanks, first on general principles; second, on account of their nuisance if not covered and troubles experienced from gas if they are covered; third, on account of their lack of ability to digest solids as claimed!"

A Government Official:

"Septic effluents when applied to sprinkling filters cause a good deal of nuisance. A sewage plant ought to be located a mile from any town."

A Consulting Engineer:

"I am in favor of septic tanks and do not think they need cause nuisance if properly operated. Septic tank effluents applied to sprinkling filters give off more odors than when applied to contact beds."

A Government Inspector:

"Septic tanks are proving to be a nuisance in many cases."

A Government Official:

"Septic tanks are proving less and less satisfactory. The original claim of 100 per cent. for sludge digestion dropped first to fifty per cent. then to twenty-five per cent.. and I personally believe it to be less than fifteen per cent. This digestion of sludge does not compensate for the nuisance involved and I think there will soon be a decided reaction against septic tanks. In several cases men have been killed by gas explosions around septic tanks."

A Rivers Board Chemist:

"I am more in favor of chemical precipitation as a preparatory process than of the use of septic tanks when trade wastes are present."

A Sewage Works Chemist:

"There are a great many cheap houses within half a mile of our works and we have had no complaint from them."

A Sewage Works Chemist:

"There is little or no odor from the works. I believe that the trade wastes tend to reduce the nuisance. Whatever odors may come from the works are due to the septic action being carried too far."

A Sanitary Inspector:

"Spraying of septic sewage on beds causes a nuisance. A dozen sprinkling filters receiving septic sewage create a smell which is objectionable anywhere within a radius of half a mile. Roughly speaking I should say that sewage works for a population of 50,000 should be located at least half a mile from dwelling houses.

A Sewage Works Manager:

"During the summer the odor from the works was so great that I believe we shall have to go back to the use of chemicals to replace septic sedimentation. In addition to the smell from the sprinkling filter we are greatly troubled by little gnats which come out of the coke and which are almost as troublesome as mosquitoes. I have noticed these at other works and they seem to be characteristic of sprinkling filters."

A Sanitary Inspector:

"Speaking of septic tanks I believe that simple settling will in the future be used more than septic treatment. In the case of sewages mixed with manufacturing wastes I believe that there will soon be a reversion from septic tanks to the use of chemicals."

A Sewage Works Chemist:

"Septic effluents are bad when used in connection with sprinkling filters if the sewage works are located in populous districts."

A Sanitary Inspector:

"Septic tanks are gradually going out of favor on account of the nuisance which they cause. We inspectors are beginning to think that there will be a gradual return to the use of chemical precipitation, but, as far as I know, no plants have yet changed back from septic tanks to chemical precipitation. Regarding the principle of septic tanks used in connection with sprinkling filters I do not consider it logical to take out all the oxygen by one process and then put it back again by the other."

An Inspector:

"I believe that septic tanks are a good thing, especially for domestic sewage, and I think that if the proper kind of a sprinkler is used there need be no serious nuisance."

A Consulting Chemist:

"I have always been opposed to septic tanks on the ground of nuisance. Those who favor the septic tanks now admit that they sometimes cause a nuisance but claim that this is due to the septic action being carried too far. In my opinion to render any sewage septic is to carry the action too far."

**Results of Preparatory Processes.** The object of the preparatory process, is to remove as much as possible of the suspended matter. It cannot be expected to remove it all. The amount left in the sewage will depend upon the amount in the raw sewage and the character of the process used. The relative efficiencies of some of the various methods used are well illustrated by figures taken from the report of Mr. George A. Johnson on Sewage Purification at Columbus, Ohio:

| | | Total Suspended Matter. | |
|---|---|---|---|
| | Normal capacity in hour's flow. | Parts per million. | Per cent. Removed. |
| Crude sewage | .. | 209 | .. |
| Grit chamber | 0.3 | 163 | 22 |
| " " | 1.5 | 138 | 34 |
| Plain Sedimentation | 6.0 | 77 | 63 |
| " " | 8.0 | 71 | 66 |
| Septic tanks | 8.0 | 82 | 61 |
| " " | 16.0 | 71 | 66 |
| " " | 24.0 | 69 | 67 |
| Chemical precipitation | 8.0 | 40 | 81 |
| Coke strainers | .. | 42 | 80 |

Generally speaking the preparatory treatment should reduce the amount of suspended matter to at least 100 parts per million, and preferably to a lower figure. In the case of some of the heavy English sewages this is not always accomplished even with the aid of chemicals. The more sludge that can be taken out by the preparatory processes without resorting to the use of chemicals the cheaper will be the cost of the entire treatment. When, however, it becomes necessary to use chemicals it becomes a nice calculation to strike the most economical balance of parts.

After the preparatory processes the treatment of sewage is conducted along two lines which must be followed separately, i. e., the purification of the liquid sewage containing the residual suspended matter, and the disposal of the sludge.

## PURIFICATION PROCESSES.

All processes which essentially alter the nature of sewage are bio-chemical. Bacterial methods of treatment are not new. The changes which took place in sewage by the older methods of sub-surface irrigation, broad irrigation, and intermittent filtration, were just as much bacterial as the newer methods of treatment by contact beds and sprinkling filters. The only difference appears to be that in the older methods the bacterial processes were not watched, while in the latter they are carefully controlled.

**Sub-surface Irrigation.** Sub-surface irrigation consists in applying sewage to land through perforated pipes laid beneath the surface. The method is an excellent one for individual houses and small institutions, but it is not applicable to the disposal of the sewage of entire communities for the reasons that large areas are required and that the drains are liable to clog up, causing heavy expenses for maintenance and operation. Furthermore, the successful operation of the method of sub-surface irrigation requires light, open, sandy soil, which can seldom be obtained at the place where it is wanted.

**Broad Irrigation.** This method is commonly spoken of as "land treatment," "broad irrigation," or "sewage farming." It consists of the application of sewage to land in comparatively small amounts in connection with growing crops, the rate of application being so adjusted that the sewage acts as an irrigant and fertilizer. Where large areas of suitable land can be obtained at low cost this method of sewage disposal is often an economical and satisfactory one. It is used to a considerable extent on the continent. The sewage of Berlin, Paris, and other large cities is taken care of in this way. Peculiar conditions are necessary for successful operation, however, such as cheap land, cheap labor, light soil, and low rainfall, especially at harvest time.

Land treatment in England has not proved very successful as the soil is not well adapted to it. The old rules of the Local Government Board required that where this method was used at least one acre of land should be provided for each 1,000 people. We were told by the inspectors, however, that in many cases it requires ten times as much land as this to properly take care of the sewage. If more sewage is applied than the land can take, the soil becomes "sewage sick," that is, it becomes clogged and unable to effect purification. During our trip we saw many sewage fields in this condition.

Experience has shown that the value of sewage as a fertilizer is very much less than used to be supposed. Sewage sludge has some manurial value, as mentioned elsewhere, but liquid sewage contains such small amounts of substances of fertilizing value that they cannot be profitably utilized. Whatever advantage accrues from the use of sewage in connection with farming operations is due far more to the water than to the solid constituents of the sewage. The idea so often expressed that sewage can be "utilized" at a profit is a dream which has never materialized.

There is a further objection to the use of sewage in connection with agriculture which has recently been made by sanitarians, namely, the danger that may come from the infection of certain vegetables which are used uncooked, as for instance, lettuce, celery, etc.

**Intermittent Sand Filtration.** Intermittent sand filtration consists in applying sewage to definite areas of porous land at regular intervals. Sometimes suitable land can be found ready for the purpose, but often specially prepared beds are necessary. The process of application is an intermittent one. The sewage is flooded over the surface and allowed to soak into the sand, after which several hours elapse during which the bed is exposed to the air. The action which takes place is a biochemical one and is essentially aerobic in character.

The results obtained by a well regulated sand filtration plant are better than can be obtained by any other known process, and when favorable conditions can be obtained this process is likewise the most economical one which can be used. Unless the conditions are favorable, however, its use will result in failure and expense. Intermittent filtration can often be supplemented by cultivation of crops, but the agricultural feature is an incidental one.

Although the method of intermittent filtration originated with England there are very few plants of that description existing there today. We did not see any during our visit. The process has been carried on with great success in Massachusetts and other parts of New England. South of the region of the glacial drift, however, suitable land is often difficult to obtain. Furthermore, as comparatively large areas are required, the method is one which cannot be well used in populous districts.

**Contact Beds.** Contact beds consist of water-tight compartments, generally built of concrete, filled with comparatively coarse material, such as coke, clinker or broken stone, and having, of course, relatively large spaces between the grains. Sewage is applied to them at regular intervals of a few hours until the bed is full, a brief period of rest is given, after which the outlet gate is opened and the liquid allowed to slowly drain away. Then the bed stands empty for a certain period and the cycle begins again. Often contact beds are operated in series, the effluent from the first being allowed to flow to a second, and the effluent from the second to a third. The secondary beds are made of finer grained material than the primary beds, and the tertiary beds are still finer. The sewage is generally applied at the top, but in some instances at the bottom. Surface distribution is made by wooden troughs placed in or over the material, or else the material itself is ridged into channels, or "grips" as they are called in England.

The action of a contact bed is partly physical and partly biochemical. If the process is properly carried out the effluent from the primary beds is fairly clear and the effluent from the secondary beds almost entirely so. This means that the suspended matter has been left in the pores of the bed. The effluent is also non-putrescent and to some extent nitrified, indicating that bacterial action has taken place. Contact beds have a controlled respiration, air being drawn into the bed as the sewage leaves it. The oxygen thus admitted acts on the suspended organic matter left in the interstices, and under the influence of aerobic bacteria changes it, or a part of it at least, to the condition of a stable humus with the formation of nitrites and nitrates. When the beds stand full the oxygen may become exhausted and for a brief interval anaerobic conditions may prevail. It is upon the oxidation processes, however, that the actions of the contact beds chiefly depend.

The largest contact beds in existence are those at Manchester, England, where they cover an area of 46 acres. They operate at the rate of about 450,000 gallons per acre daily. There is but one series of beds in use, but it is intended to build secondary beds at an early date. Septic sedimentation is used for the preparatory treatment. The contact method has been in use since 1901. The effluent is discharged into the Manchester Ship Canal. Its quality has not been up to the standard of the Mersey-Irwell Joint Committee, i. e., 1.0 grain per gallon of oxygen consumed in four hours, although the degree of purification has been fairly satisfactory for single contact beds. The effluent from the one secondary bed now operating is good.

At Burnley there are both primary and secondary contact beds, and although the plant is not as large as that at Manchester, it is in some respects a more interesting plant to visit. Here the effluent from the secondary beds is generally within the requirements of the Mersey-Irwell Joint Committee. The plant has been in operation for about eight years.

The rate of filtration of a contact bed depends upon the character of the sewage, the size of the grain, the depth of the bed, the amount of clogging, etc. A common rate in England is 500,000 gallons per acre daily ; with weak sewages and with efficient preparatory treatment it may be nearly double this amount, but with the strong English sewages it is sometimes unsafe to apply more than 300,000 gallons per acre per day. The rules of the Local Government Board prescribe that the rate shall not exceed 325,000 gallons per acre daily for each foot in depth when the effluent is to have subsequent treatment. Double contact beds are required when it is not. Contact beds naturally lose their capacity as they become clogged. After a time it becomes necessary to remove the filtering material, wash off the accumulation and restore it to the beds. At Manchester, Burnley, Hampton, and elsewhere the contact beds are now being cleaned and renewed. The coke or clinker filling is generally cleaned by washing and screening through cylindrical revolving screens which separate the material into different sizes. A washing apparatus with suitable conveyors is just as essential a part of a sewage purification works where contact beds are used as is a sand washer in a modern filtration plant. Thus far those which have been used have been crude and of a temporary character, and there is a chance for decided improvement in their design. The frequency with which contact beds have to be renovated cannot now be determined with certainty, as many factors are involved and the data are as yet insufficient. There seems to be a feeling among English engineers, however, that primary beds operating at average rates on ordinary domestic sewage may be counted upon to last from three to seven years, while secondary beds may last from eight to fifteen years. At Manchester no renewals were made till the beds had been in operation nearly five years, and even now they are renewing only one-third of each bed, namely, those parts under the grips, where the clogging naturally is greatest.

Properly operated double contact beds yield effluents which are reasonably free of suspended matter and color, and which are nonputrescible. Many contact beds have failed because they have been overworked or because the regimen of operation has not been suited to local conditions.

Contact beds have one advantage over other purification processes. Their depth can be varied at will, as their efficiency is not so dependent upon depth as in the case of sprinkling filters. They have been built as shallow as two feet. When sewage works are so located that there is little available head therefore contact beds are especially applicable. They can be operated also with less nuisance from odor than sprinkling filters can, especially when filled from the bottom. For small gravity installations contact beds are especially useful, as they can be made to operate with comparatively little attention.

The most recent idea in the construction of contact beds is the use of slates laid in layers separated by blocks about two inches high. These are called "Plate Contact Beds" by Mr. W. J. Dibdin, who suggested them. The advantages claimed for them are greater void space, better occlusion of air, and easier cleaning. There is an interesting plant constructed on this system at Devizes, near Bristol.

**Sprinkling Filters.** Perhaps the most important advance in sewage disposal during the last few years is the general recognition of the sprinkling filter as an efficient means of purification. This is also called "trickling filter," "continuous filter" and "intermittent continuous filter." The term "percolating bed" has also been suggested, as well as "spray filter." A sprinkling filter, like a contact, is composed of relatively coarse material. Its operation, however, is very different. Instead of being worked on the fill and draw principle, the sewage is continuously applied at the surface, either as a spray or in a thin sheet. The outlet gate is kept open and the sewage trickles down through the bed and passes out of the underdrains which are made large and open so as to insure a thorough aeration of the entire bed. The process is emphatically an aerobic one. Air is continuously entering the bed with the water and passing in or out through the under-drains, and sometimes through the sides of the filter. As the liquid flows rapidly through the bed and as no sewage is supposed to accumulate in the bed, there is really no need of side walls, and in some cases these are omitted, the material being allowed to take its natural slope. More often, however, loose walls of brick or stone are built up to retain the material.

The filtering material used is generally coke, clinker, or broken stone. There is some difference of opinion as to the best size to be used. Some engineers prefer what are called "fine grain beds" in which the diameters of the particles lie between ⅛-inch and 1-inch. Thus, at Hanley, which is perhaps the best illustration of a fine grain sprinkling filter, the material consists of three equal layers which together make a depth of five feet. The coarsest, which is at the bottom, is screened between ¾-inch and 1-inch, the middle layer between ¼-inch and ½-inch, and the top layer between ⅛-inch and ¼-inch. The material used is known as saggers. It is obtained by crushing the broken pottery jars in which china is baked. More often "coarse grain filters" are used and material screened between 1-inch and 3-inch screens is very common. In rare instances even coarser material is used. Both fine grain and coarse grain filters have their advocates, but the latter appear to be generally preferred. Fine grain filters yield clearer effluents, but as a result they become clogged, while aeration is rendered more difficult. Coarse grain filters, on the other hand, do not clog as readily and therefore their life is longer and the ventilation better, but the effluent is more or less turbid.

The application of the sewage to the bed is a matter of great importance and one which has been carefully studied by English engineers. Many patented devices are on the market for accomplishing it. As aeration is important, the more the applied sewage can be subdivided into small drops the more efficient will be the process. One of the earliest ways of applying the sewage was to allow it to flow through small holes in troughs placed over the surface of the bed. This method has been found to have its disadvantages. The holes are liable to become filled up and the troughs tend to get out of level, thereby causing unequal distribution of the sewage.

Rotary sprinklers are much in vogue in England. They consist of four arms mounted on a central vertical shaft so that they revolve in a horizontal plane immediately above the surface of the bed. The arms are perforated only on one side, and, the sewage being discharged through them, the apparatus is made to rotate on the principle of Barker's mill. These rotary sprinklers are now so common in England, espically for small plants, that they have become a characteristic feature of the landscape as one looks from the car windows in certain sections of the country. Some of the largest rotary sprinklers are 120 feet in diameter and are operated with power instead of in the manner above indicated. In some cases the outer end of the sprinkler is carried on a circular track laid around the bed.

Some of the objections which have been raised against the use or rotary sprinklers are that the holes tend to become clogged, and that the wind interferes somewhat with the rotation. They also require circular instead of rectangular beds, although in some cases several rotary sprinklers have been placed in large rectangular beds, the dead corners being sprayed from fixed nozzles. The intermittent application of sewage which is obtained by the use of the rotary sprinkler is thought by some to have decided advantages.

Instead of using rotary sprinklers the sewage is sometimes applied to rectangular beds by means of a perforated pipe mounted so as to travel back and forth laterally. This is the arrangement used at Hanley. The pipe is carried on trucks at the ends, which run on rails along the sides, and which are operated by electricity.

The movable devices appear to be satisfactory for small installations, but they cannot be applied to large beds. When filters reach a size of an acre or more, permanent jets give a better distribution of the sewage. The first large plant of this kind to be erected was that at Salford, England, but the beds which are being constructed at Birmingham surpass it in area. The sprinklers there used are said to give general satisfaction. The managers say that they gradually become clogged and that it is necessary to clean them out at frequent intervals. The strainers recently devised for the Columbus plant appear to be a decided improvement over any in use in England. The sprays are generally operated under a head of about four feet and the applied sewage usually rises to a height of one to two feet above the surface of the bed.

The purification which takes place in the sprinkling filter is due entirely to the action of aerobic bacteria. The suspended matter in the applied sewage settles on the grains as the liquid passes through until gelatinous films are formed. Being liberally supplied with air, the organic matter gradually undergoes decomposition and changes its character, becoming somewhat granular and more like the condition of ordinary top soil. When the accumulation has reached a certain point films of this accumulated matter break away from the grains and are discharged with the effluent. To a certain extent this process is continually going on, so that the effluent is never wholly free from turbidity, but it has been noticed that there is an unloading of the accumulated sediment at more or less regular intervals. This may be caused by an accelerated rate, by conditions which affect the bacterial action, and by the action of worms. This unloading of a sprinkling filter, which was at first thought to be a serious objection, is now believed to be its most important advantage, as it prolongs the life of the bed. There are coarse grain sprinkling filters now in use which have been operated continuously for seven or eight years and which are apparently in good condition. How much longer these filters can be operated is something that engineers will watch with interest. It would be a mistake to suppose that they will last indefinitely, but if the material is properly chosen and the sewage is applied at the optimum rate, there seems to be no reason why they may not run ten to fifteen years before they are renewed.

The rate at which sewage can be applied to sprinkling filters varies according to the character of the sewage, the depth of the filter, the size of the grains, etc. Deep filters can operate at higher rates than shallow filters, and are generally to be preferred. Filters less than five feet deep do not operate satisfactorily, as the time required for the sewage to flow through them is too short. On the other hand, filters deeper than about 12 feet may involve difficulties in ventilation and in matters of engineering. Depths of 7 to 8 feet are generally preferred. Experiment has shown that between 5 and 12 feet the amount of sewage which can be applied in a unit of time varies approximately with the depth—that is to say, a 10-foot filter can take twice as much sewage as a 5-foot filter. The rate which will give the most efficient purification varies inversely as the strength of the sewage. It has been found that for any depth of a sprinkling filter there is a more or less definite amount of organic matter which must be applied in a unit of time to give the best results; in other words, the size of a sprinkling filter is governed fully as much by the number of people contributing sewage to it as by the number of gallons of sewage applied The rules of the Local Government Board prescribe a limiting rate of 325,000 gallons daily per acre for each foot of depth when the effluent is to receive further treatment, and 162,500 gallons per acre daily when the effluent is to be directly discharged to the river. Considered on the basis of domestic sewage this would be equivalent respectively to an application of 30 grams and 15 grams per square meter daily of total nitrogen. Experiments made at Columbus, at Lawrence and elsewhere, appear to indicate that in order to obtain effluents which are well nitrified and which are not putrescible the amount of nitrogen applied should not exceed 25 grams per cubic meter daily, or in other words, that each acre of a sprinkling filter should not receive sewage from more than about 2,000 people for each foot of depth. Carbonaceous matter must be considered, however, as well as the nitrogenous matter, and there is an opportunity for further study in connection with this subject.

If sprinkling filters are properly operated they will yield an effluent which is non-putrescible and well nitrified. If coarse grains have been used it will contain more or less suspended matter for reasons above mentioned, but this suspended matter will be very different in character from that present in the raw sewage.

The purification effected by sprinkling filters seems to be generally better than that obtained by contact beds.

The chief advantages of sprinkling filters are that the purification is good, that the effluents are well nitrified and non-putrescible, that the filters do not become clogged except at very long intervals, and that the rate of application of the sewage is considerably greater than can be obtained by any other process, thereby reducing the amount of area required. Certain disadvantages are the nuisance occasionally produced by spraying septic tank effluents, and the difficulty of properly applying the sewage during the cold weather of winter. The odor nuisance may be avoided to a practical extent, however, by reducing the degree of septicity of the sewage—that is, by spraying stale sewage instead of septic sewage. Experiments at Columbus indicated that sprinkling filters with permanent jets can be operated during cold weather, but this is something which has not yet been tested on a large scale. The idea has been suggested, that in case sprinkling filters fail during the winter months they may be so arranged as to be operated as contact beds during the cold weather. The climate of England is mild even during the winter, and therefore this is a problem which it has not been necessary to solve in that country. In our southern states there would be no difficulty at all in using sprinkling filters at all seasons, and even in the north there is reason to believe that ways and means will be found for successfally operating them.

### English Opinions as to Contact Beds and Sprinkling Filters.

The following extracts from my diary show the decided leaning of English experts in favor of sprinkling filters:

A Consulting Chemist.

"I think that good results can be obtained either by the use of contact beds or sprinkling filters. Generally speaking, however, I prefer the latter. In the use of sprinkling filters care should be taken to apply the sewage properly. I am not in favor of the spraying nozzle as the sprayed sewage makes a nuisance and there is danger that pathogenic bacteria may be blown into the atmosphere and scattered."

A Consulting Chemist:

"I prefer contact beds to sprinkling filters because they are less expensive. Even if contact beds have to be renewed every four or five years I claim that these renewals are cheaper than the interest on the more expensive structures required with sprinkling filters."

A Government Chemist:
"Contact beds are good, but sprinkling filters are better."

A Consulting Engineer:
"Contact beds are of more general adaptation than sprinkling filters because they can be used with any head from 6 inches to 10 feet. Contact beds can be built to fit any conditions. Sprinkling filters are more of a nuisance than contact beds, and revolving sprinklers are unsatisfactory as the jets clog up and the wind impedes their rotation."

A Government Inspector:
"Both contact beds and sprinkling filters give good results. More depends upon the operation than upon the system used. Personally I favor sprinkling filters."

A Government Official:
"Good results can be obtained either by contact beds or by sprinkling filters. The cost of renewal of contact beds is at present an unknown quantity. All things considered deep sprinkling filters composed of coarse grains have proved the most satisfactory. Depths of 8 to 10 feet generally give the best results."

A Rivers Board Chemist:
"Sprinkling filters are better than contact beds. I prefer coarse material, particularly coke. The depth should be varied according to the quality of the sewage. A depth of 5 feet is all right for dilute sewages, but greater depths are necessary if the sewage is strong."

A Sewage Works Chemist:
"Personally I favor contact beds as opposed to sprinkling filters on the ground of cost and nuisance. Either method, however, can be made to work satisfactorily."

A Rivers Board Inspector:
"Sprinkling filters and contact beds have practically the same efficiency if properly designed and properly cared for. Data are not yet available to show with certainty the relative costs of the two systems. So far as the figures go, however, they indicate that the greater first cost of sprinkling filters is justified on account of the reduced cost of maintenance. I prefer a coarse grain filter."

A Sewage Works Engineer:
"I believe that the principle of sprinkling filters is the correct one."

A Sewage Works Manager:
"Our sprinkling filters are 9 feet deep filled with coke ranging from 1¼ inches to 4 inches in diameter. The beds have been running two years and have never given the slightest trouble. They have never been cleaned or forked over."

A Sewage Works Manager:
"We have two sprinkling filters which have been operating for 7 years with good results. They have never been cleaned and they are not clogged."

A Rivers Board Inspector:
"I am in favor of sprinkling filters and prefer rather fine beds for the use of domestic sewage, or rather beds constructed of mixed materials."

A Sewage Works Engineer:
"Experiments with our sewage indicated that sprinkling filters were much better than contact beds. The latter clog badly. With our sewage, however, we cannot main-

tain sprinkling filters permanently without renewal of the material. This is on account of the large amount of suspended matter and fat that the sewage contains."

A Sewage Works Chemist:

"In our experiments with city sewage sprinkling filters gave better results than contact beds. I prefer coarse material."

A Rivers Board Inspector:

"Sprinkling filters offer the best means of purifying sewage at the present day. It is very important, however, to have them well ventilated."

A Rivers Board Inspector:

"I am an earnest advocate of sprinkling filters using fine grain material."

A Consulting Chemist:

"I am opposed to the use of contact beds and believe that sprinkling filters are the only logical method."

**Results Obtained by Purification Processes.** The success of intermittent filtration and broad irrigation in purifying sewage where suitable conditions for their application exist has been demonstrated by many years of experience. The practical application of contact beds and sprinkling filters covers a much shorter period of time, yet it has been long enough to demonstrate that these newer processes may be successfully depended upon if the plants are properly designed and carefully operated. The degree of purification obtained varies greatly under different conditions. Sprinkling filters generally give somewhat higher percentage efficiencies than contact beds.

The new processes of sewage purification are sometimes spoken of as the "intensified bacterial processes." That this term is well justified, in so far as it relates to the size of the works, seems evident from the following figures which give in a very approximate manner the relative sizes of the plants required by the four important methods of purification.

APPROXIMATE DATA AS TO SIZES OF PURIFICATION PLANTS.

| Method. | Nitrogen in grams per square meter daily. | Rate of filtration gallons per acre daily. | Population per acre. | Number of acres required per 1,000 people. |
|---|---|---|---|---|
| Broad Irrigation, | 1 | 3,000 to 15,000 | 300 | 3.3 |
| Intermittent Filtration, | 2.5 | 30,000 to 100,000 | 700 | 1.4 |
| Contact Beds, 5 feet deep, | 20. | 300,000 to 800,000 | 5,000 | 0.2 |
| Sprinkling filters, 10 ft. deep, | 75. | 1,000,000 to 2,500,000 | 20,000 | 0.05 |

It will be seen from these figures that more than twenty times as much sewage per unit of area can be treated by sprinkling filters as by the method of intermittent filtration. The results with the new processes, to be sure, are not quite as satisfactory, but the effluents are stable and fit to be discharged into streams not used for purposes of water supply. The above figures showing the approximate sizes of plants are not to be taken as applicable to any particular case, especially when manufacturing wastes are included. Each local problem must be studied by itself. In some instances the number of acres required might be double the figures given; often the area might be considerably less. The rate of sprinkling filters depends largely upon the size of grain used. In some recent American designs much higher rates have been recommended than those given above.

## FINISHING PROCESSES.

The effluents obtained from sub-surface irrigation, broad irrigation, and intermittent filtration methods require no further treatment if the plants are properly designed and carefully operated. They are usually clear enough for all practical purposes, non-putrescible and reasonably satisfactory from the bacterial standpoint. This is not true, however, of effluents from contact beds or sprinkling filters. Contact effluents, as well as those from fine grain sprinkling filters, may be clear and even non-putrescible, but bacteriologically they are not good enough to be turned into streams which are used for public water supply purposes, or into tidal estuaries where there is danger that oysters may be contaminated. The effluents of coarse grain sprinkling filters are not clear, but contain large amounts of suspended matter as already pointed out.

**Clarification.** A finishing process is therefore necessary when coarse grain sprinkling filters are used. As the suspended matter in these effluents is comparatively coarse and heavy it settles readily and may be removed by the use of shallow settling basins with a short period of sedimentation, or by rough filtration through coarse material, or both. Dortmund settling tanks also have been tried with success. A popular method in England at the present time is to allow the sprinkler effluent to pass through a shallow settling basin, which has a narrow strip of coarse filtering material placed along the side near the outlet. The liquid is made to pass upwards through this rough filter before it is discharged. These settling basins and filters have to be cleaned at rather frequent intervals, a fact which has to be taken into account in figuring operating expenses. The sludge, however, is practically inoffensive and may be more easily handled than that from the settling tanks used for the raw sewage. In some instances the effluent from sprinkling filters is applied to land in order to clarify it, but this has usually been done in order to take advantage of land already owned. No new works are being constructed which involve this feature.

**Bacterial Improvement.** Experiments which were made at the London works and elsewhere have shown that from the standpoint of contamination the effluent from sprinkling filters or from contact beds is but little better than that of the raw sewage, and that while the organic matter is eliminated from the sewage to such an extent that the liquid is non-putrescible, yet the number of intestinal bacteria and presumably the number of pathogenic bacteria, in case the sewage is infected, are not by any means eliminated, though reduced somewhat in number. It is not safe therefore to turn the effluent from a contact bed or sprinkling filter into a stream which is to be used for drinking purposes at some point below the point of discharge. The danger of the contamination of oysters from sewage is now well recognized, and this will have an important bearing on the character of sewage effluents in many places.

In certain cases therefore supplementary processes are necessary to eliminate the dangor of infection from sewage effluents. These may consist of disinfection, or of some one of the methods used for purifying water. Broad irrigation or intermittent filtration might be used. Mechanical filtration has also been suggested. The use of certain disinfectants, such as copper sulphate, chloride of lime, etc., have been studied experimentally, but so far as I am informed, they have not been practically used. This subject of supplementary treatment in order to minimize the danger from infection by sewage effluents is one which has not yet been as carefully studied as it seems likely to be in the near future.

**Sludge Disposal.** The disposal of sludge is the most difficult matter in connection with sewage disposal. The progress here has not been as rapid during the last few years as in connection with the treatment of liquid sewage. Managers and engineers all admit that the sludge problem is still *the problem* of sewage disposal; nevertheless, there has been some advance made of late. The change from chemical precipitation to the use of septic tanks has very materially decreased the amount of sludge to be handled, and it has, moreover, changed the character of the sludge so that it need not now create as much nuisance as formerly.

There are three principal methods of sludge disposal: (1) dumping at sea, (2) application to land, and (3) pressing into cakes. Carrying the sludge to sea and there dumping it is the most efficient means of getting rid of it. It is, however, the most expensive, and is not practicable except in a few cities favorably situated. Application to land, if it can be carried on in the immediate vicinity of the sewage work, is the cheapest method, but it is likely to create more or less nuisance. Mr. Watson's experience at Birmingham already referred to is very interesting in this connection. He has found that, while ordinary sludge from settling tanks cannot be spread upon land without creating offensive odors, sludge which has passed through the process of digestion in the septic tank is inoffensive when similarly disposed of. Such sludge which, in one instance, was spread upon a five-acre field to the depth of 1.5 feet gradually dried and settled until it consisted of a layer of what looked like ordinary top soil about six inches thick. It was thought at first that crops could be grown on the dried sludge, but this did not prove to be practicable unless earth was mixed with it.

Sludge cannot be easily pressed without the addition of lime, and septic sludge is more difficult to press than either the sludge from chemical precipitation tanks or from plain settling tanks. It requires more lime and more care in operation. Nevertheless, in some places it is done with apparent success.

The value of pressed sludge seldom equals the cost of lime and pressing. In some places where the pressed cake is used for manurial purposes the amounts received from the farmers just about pay the operating expenses, while in other cases the process is carried on at slight loss.

Pressed cake appears to have just about the same manurial value as an equal weight of barnyard manure. It has been found, however, that it does not give good results as a fertilizer when applied continuously year after year to the same piece of land. That is one reason why its sale usually drops off a few years after the sewage plant has been established.

Some sewage sludges are so rich in fats that it is practicable to use them for fuel, or even to recover the grease. The recovery of the grease does not interfere with the later use of sludge for fertilizer as the nitrogen is not extracted. The sludge from the settling basins receiving the effluent of sprinkling filters is much less offensive than ordinary sludge. It can be applied to land with practically no nuisance.

At Birmingham, England, where the sludge appears to be well handled for an inland city, it is said that the general level of the land in the vicinity of the settling tanks is being raised at the rate of about one inch a year.

**Disposal of Storm Water.** As so many of the English cities are sewered on the combined system the disposal of storm water is an important part of any system of disposal. The rules of the Local Government Board of England require that sewage works shall be built large enough to treat twice the dry weather flow in case of separate systems and three times the dry weather flow in case of combined systems, at the rates prescribed on a previous page. A further treatment of storm water is required up to four volumes of dry weather flow in the case of separate systems, or three volumes in case of combined systems. The prescribed minimum rate of treatment on storm beds is 2,900,000 gallons per acre daily. In both cases, therefore, storm flows must be treated in one way or another up to a volume of six times the dry weather flow. An excess above this may be discharged directly in a stream without treatment.

Storm water is very commonly treated on beds of coarse material operated continuously as long as the storms last but having long periods of rest between. In order to keep the beds in good condition, however, they are often allowed to receive sewage in small amounts during the dry periods, but care has to be taken that they are not clogged when needed for full duty. During times of storm the period of sedimentation is much reduced, so that suspended matter is often carried to the storm beds in rather large quantities. This, together, with the grease which is often present in large amounts, may give rise to surface clogging. Storm beds therefore require to be scraped at frequent intervals, or to have the upper layer of material removed and washed.

Instead of using coarse grain beds storm water is sometimes turned upon land. It is often the case that when contact beds or sprinkling filters have replaced the older process of land treatment, that the old areas are reserved for treatment of storm water.

**Disposal of Purified Effluent.** The object of purifying the sewage is chiefly to prevent it from being a nuisance to sight or smell when discharged into some body of water. In certain instances it is further demanded that the effluent shall be satisfactory from a sanitary point of view in order to avoid danger of contamination of water supplies or oyster beds.

The subject of sewage disposal by dilution and the effect of sewage effluents on the quality of water in streams and tidal estuaries was one that we studied in England only incidentally. The success of methods of sewage purification in yielding a stable effluent which could be turned into streams without giving offence already has been mentioned. The various rivers boards of England have established certain working standards of purity of sewage effluents. These vary somewhat in different sections, and, as they are based upon English methods of analyses which differ somewhat from American practice, no description of them will be here given.

At Belfast, Ireland, Mr. Hewat obtained some interesting information in regard to the effect of the discharge of the raw sewage of that city into the Belfast Lough. It seems that the shores of Belfast harbor in the vicinity of the sewage outfalls have become covered with immense growths of a green seaweed known as *Ulva Latissima,* or sea lettuce. This makes its appearance in spring and summer in enormous quantities and is driven ashore by the wind in such masses that when it putrefies it gives rise to an intolerable stench felt over a wide area. This alga has been carefully studied by Dr. E. A. Letts, Professor of Chemistry in Queens College. He has found that it has remarkable powers of assimilating nitrogen in the form of ammonia or nitrates. He attributes the present intense growths to the free ammonia of the sewage. Looking forward to the future he fears that one effect of the proposed treatment of the sewage by means of septic tanks and contact beds may tend to increase rather than diminish these algae growths. As a result of experiments which he has made he concludes, however, that by mixing a certain amount of septic tank effluent with the effluent from the contact beds the free ammonia and nitrates can be changed to gaseous nitrogen, a form which will not be assimilated by the algae.

## DATA SHOWING METHODS OF SEWAGE DISPOSAL IN THOSE CITIES OF ENGLAND AND

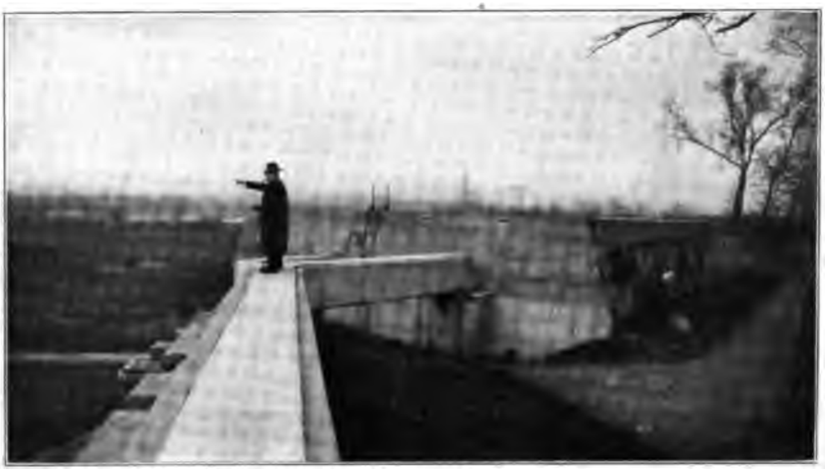
| | London | Hampton | Castle Douglas | Glasgow Dolmui Works | Edinburgh | Manchester | Salford | |
|---|---|---|---|---|---|---|---|---|
| Population | 5,137,000 | 2,000 | 3,000 | .......... | ......... | 575,000 | 250,000 | 33,0 |
| Average dry weather flow in million gallons daily | 300 | 0.25 | 0.08 | 40 | ......... | 33 | 16 | 1 |
| Volume of sewage gallons per capita daily | 59 | 36 | 37 | .......... | ......... | 58 | 60 | |
| Character of sewage | d (m) | d | d | d m | d m | d m | d m | d m |
| System of sewerage | c | s | s | c | c | c | c | c |
| Preparatory Processes: | | | | | | | | |
| Screens | x | x | x | x | x | x | x | x |
| Roughing filters | | | x | | | | 1 | |
| Detritus tanks | | | | x | | x | x | x |
| Plain settling tanks | | | | | | x | | |
| Chemical precipitation tanks | x | | x | x | | | 1 | |
| Septic tanks | | x | | | | 1 | | x |
| Purification Processes: | | | | | | | | |
| Sub-surface irrigation | | | | | | | | |
| Broad irrigation | | | | | (1) | | | |
| Intermittent sand filtration | | | | | | | | |
| Contact beds, single | (1) | | | | | x | | |
| Contact beds, double | | | | | | (1) | | |
| Contact beds, triple | | x | | | | | | |
| Sprinkling filters | | | | | | | 1 | x |
| Sprinkling filters, double | | | | | | | | |
| Finishing Processes: | | | | | | | | |
| Settling basins | | | | | | | | x |
| Coarse filtration | | | | | | | | x |
| Land treatment | | (1) | | | | | | |
| Sludge Disposal: | | | | | | | | |
| Sea disposal | x | | | 1 | | x | x | |
| Land treatment | | 1 | | 1 | | | | 1 |
| Pressing | | | | 1 | | | | 1 |
| Sale to farmers | | | | 1 | | | | 1 |
| Recovery of grease | | | | | | | | |
| Burning under boiler | | | | | | | | |
| Effluent disposal | | | | | | | | |
| Into tidal estuary | x | | | x | x | | | |
| Into stream | | x | x | | | x | x | x |

NOTES:—d=domestic; m=manufacturing; c=combined system; s=separate system; x=all of the sewage;

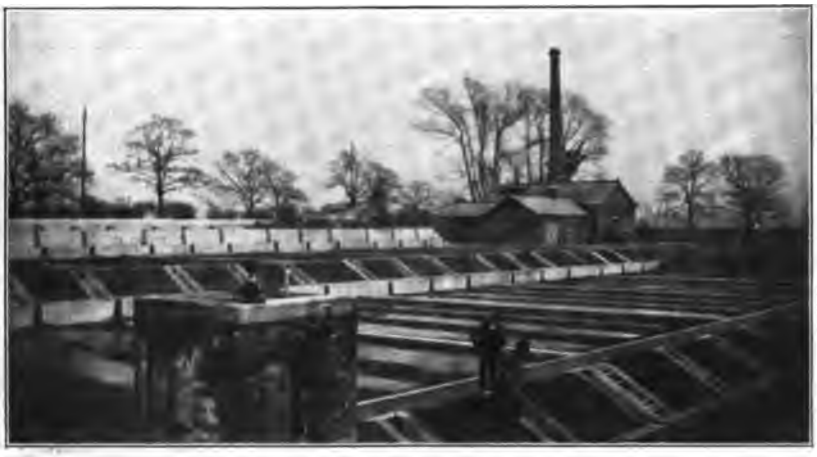
## ) IRELAND, VISITED BY MESSRS. WHIPPLE AND HEWAT IN MARCH AND APRIL, 1906.

| Hyde | Macclesfield | Norden | Rochdale | Chester | Darwin | Burnley | Bradford | Leeds | Birmingham | Hanley | Lisburn, Ireland | Belfast | Liverpool |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ,000 | 35,000 | ...... | 76,000 | 47.000 | 40,000 | 82,000 | 280,000 | 444,000 | 793,000 | ......... | 12,000 | 350,000 | ......... |
| 1.2 | 1.2 | ...... | 2.3 | 2.0 | 0.75 | 2.25 | 15.5 | 19 | 30 | 36 | .30 | 7 | ......... |
| 36 | 34 | ...... | 31 | 43 | 19 | 28 | 55 | 43 | 38 | ......... | 25 | 20 | ......... |
| m | d m | m | d m | d | d | d m | d m | d m | d m | d m | d | d m | d m |
| c | c |  | c | c | c | c | c | c | c | s | c | c | c |
| x | x | x | x | x | x | x | x | x | x | x | x |  |  |
| x | x |  |  | x |  |  | x | x | x | x |  |  |  |
|  |  |  |  |  |  |  | x | x |  |  |  |  |  |
| K | x |  | 1 | 1 | 1 | x |  |  | x | x | x |  | 1 |
|  |  |  | x |  |  |  |  |  | 1 |  | 1 |  |  |
|  |  |  |  |  |  | x |  |  |  |  | x |  |  |
| ( | x |  | 1 |  | x |  |  |  | x | x |  |  | 1 |
|  |  |  |  | x |  |  |  |  |  |  |  |  |  |
| ( |  |  | 1 |  | x |  |  |  |  |  |  |  |  |
| ( | x | x |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | 1 | x |  |  |  |  |  |  |  |  |
|  | 1 |  | 1 | 1 | x | x |  | x | x | x |  |  |  |
|  | 1 | x | 1 |  |  | 1 | x |  |  |  |  |  |  |
|  | 1 | x | 1 | 1 |  | 1 | 1 |  |  |  |  |  |  |
|  |  | x |  |  |  |  | 1 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |
|  |  |  | x |  |  |  |  |  |  |  |  | x | x |
| : | x | x |  | x | x | x | x | x | x | x | x |  |  |

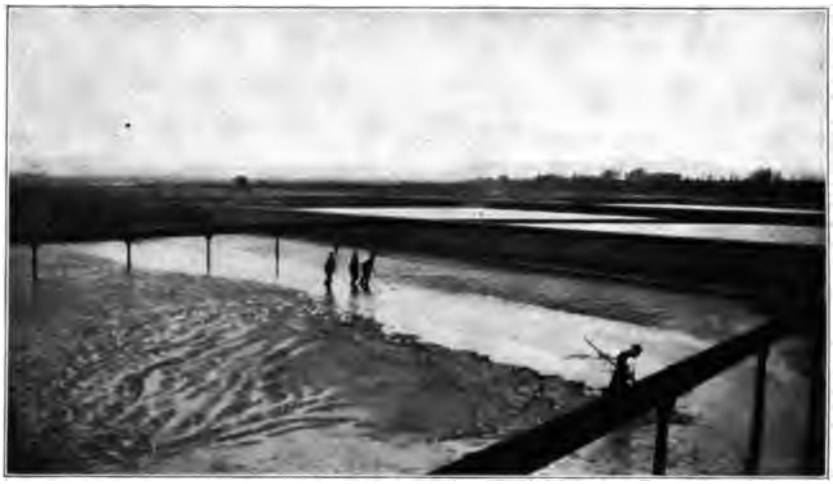
1 =part of the sewage ; ( )=small amount.



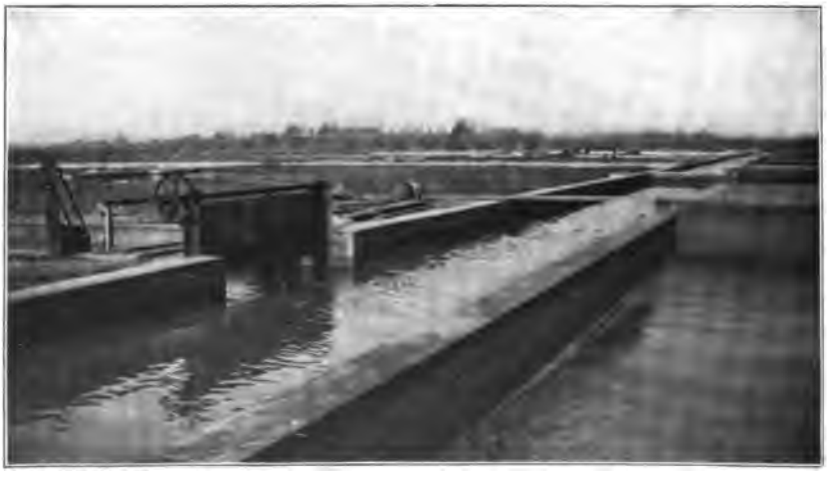
Hampton :—View of hydrolytic tank, showing concrete conduit which conveys the raw sewage from the pumping station to it.



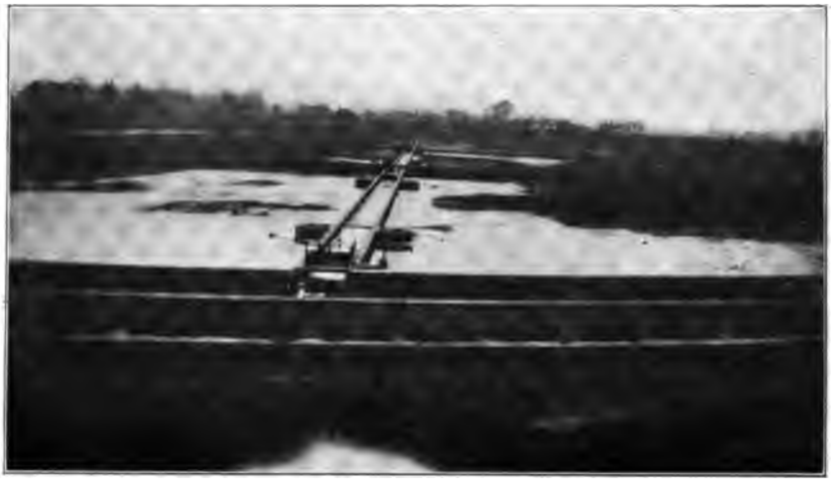
Hampton :—View of contact beds with pumping station in the distance. There are three sets of beds, but the tertiary beds are not shown in this photograph.



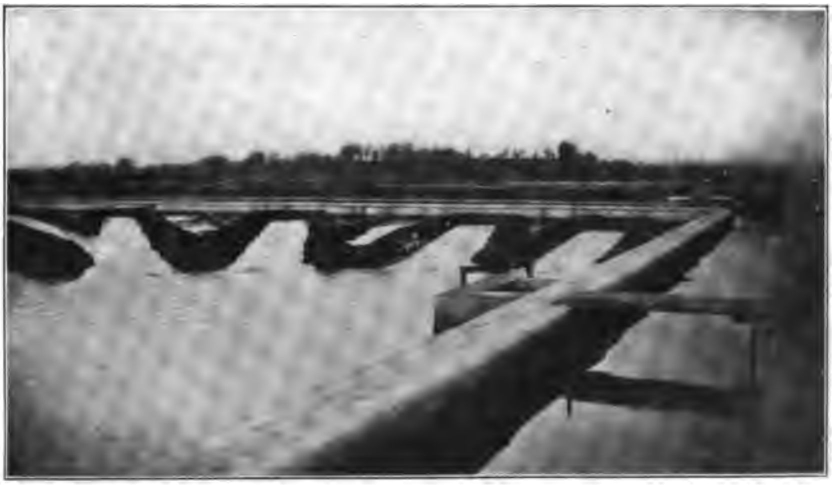
Manchester:—View of one of the sedimentation basins taken during the process of cleaning. In certain parts of this basin the sludge was about two feet deep. The sludge is pushed to one end of the basin and pumped to scows which take it to sea. The view shows the scum boards built across the basin.



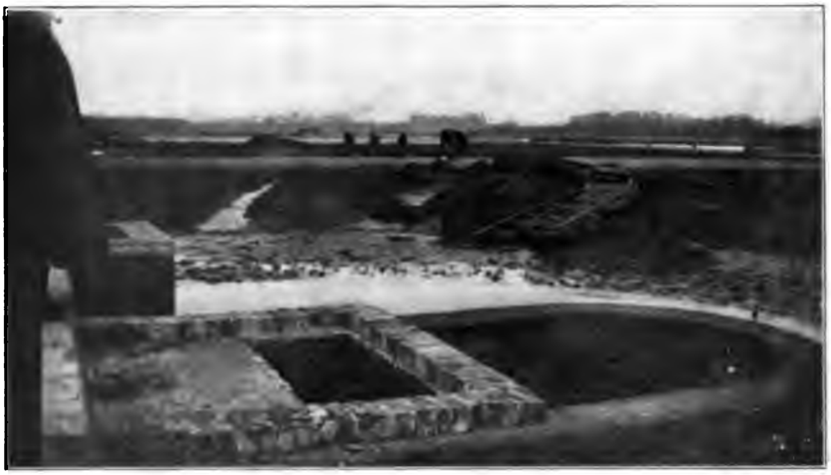
Manchester:—General view of one of the distributing conduits.



Manchester:—View of one of the storm beds showing manner of distribution of sewage over the surface.

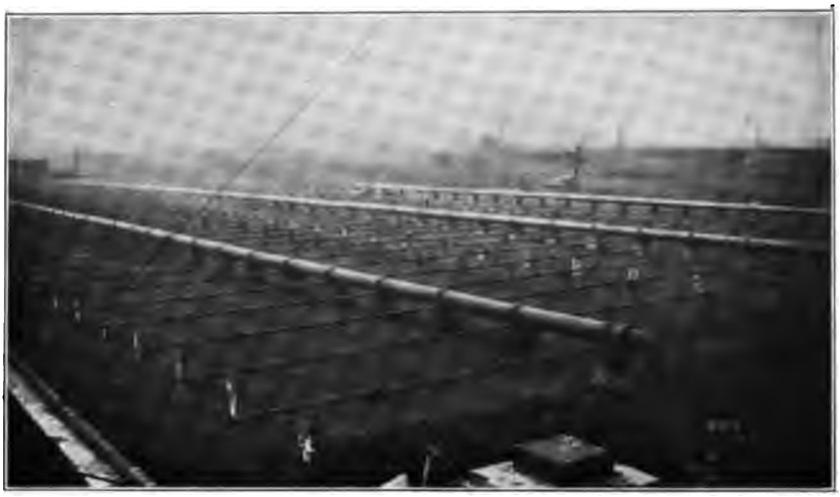


Manchester:—Another view of one of the contact beds showing a different method of gripping.

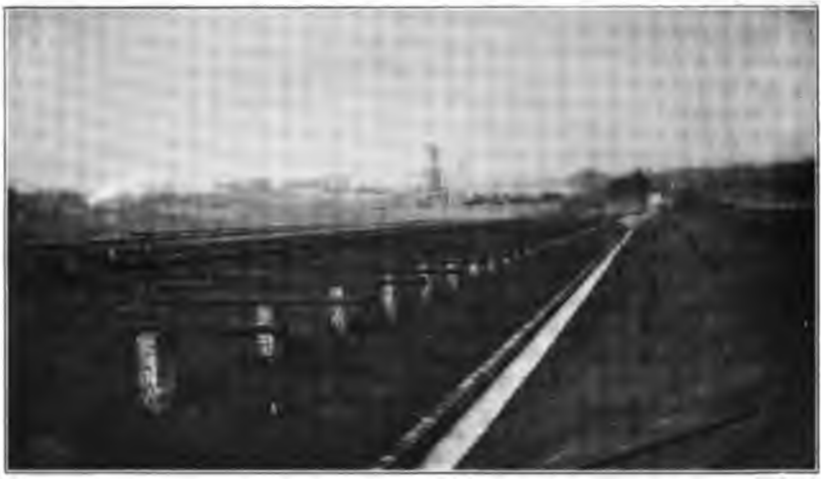


Manchester :—View of one of the contact beds in which the material was being removed for cleaning.

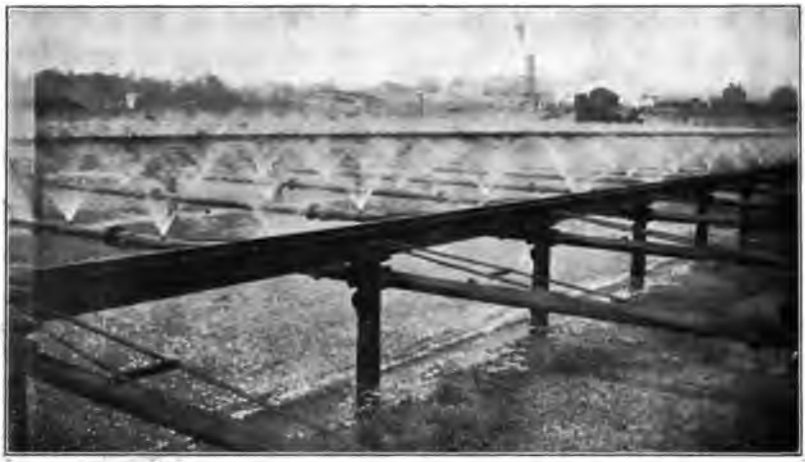
Manchester :—View of Manchester Ship Canal showing sludge boat.



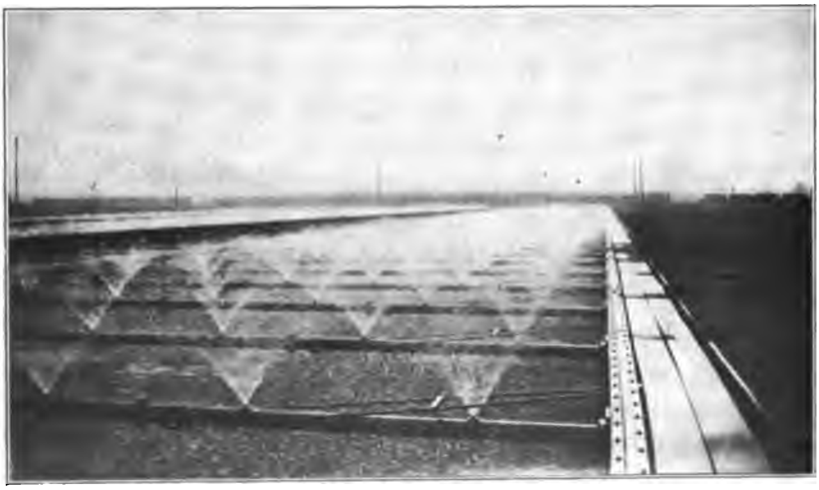
Salford :—General view of one of the sprinkling filter beds. Six sprinkling filter nozzles are placed on each lateral.



Salford :—View of the side of one of the sprinkling filters showing main effluent channel.



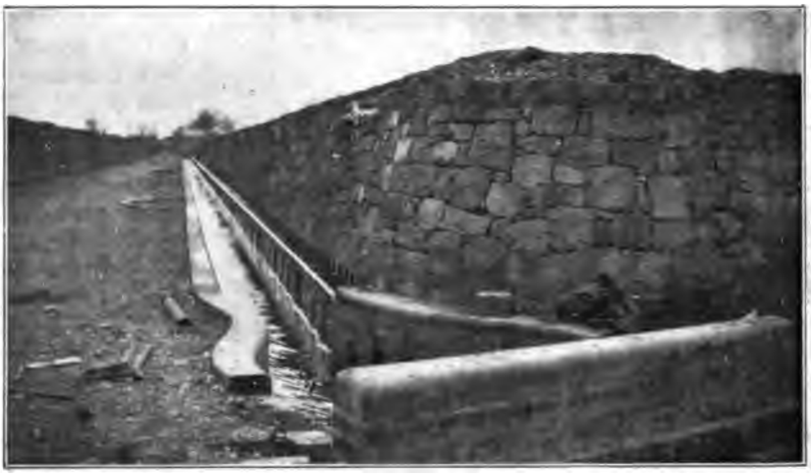
Salford:—View of one of the sprinkling filters in operation. This bed was somewhat clogged and the sewage was pooled on the surface in certain parts of it.



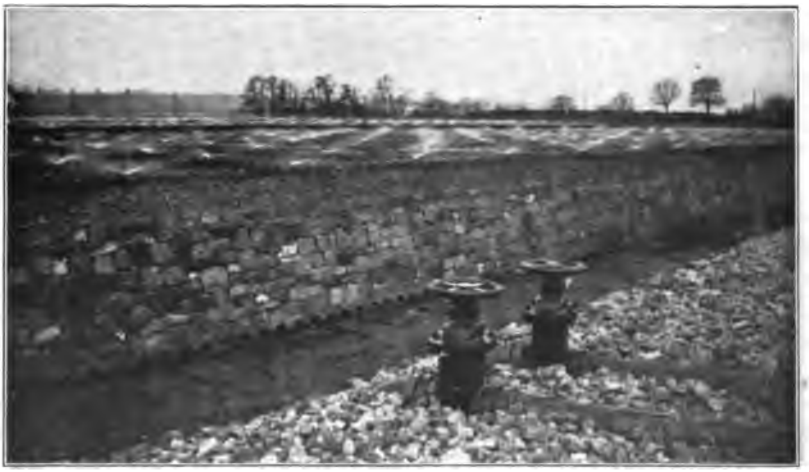
Salford:—Nearer view of one of the sprinkling filter beds in operation.

Birmingham:—View of one of the circular sprinkling filters. This bed was 120 feet in diameter and about 7 feet thick. The sewage was operated by means of a revolving sprinkler.

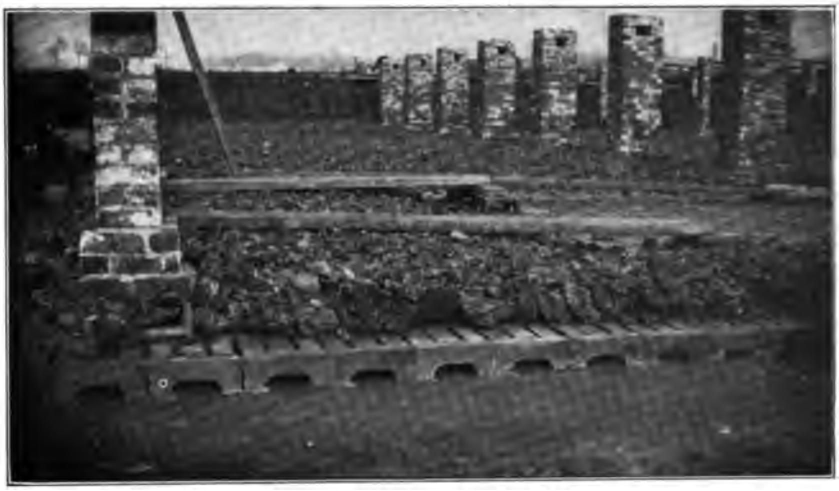
Birmingham:—View of the device used for washing clinker taken from one of the storm beds.



Birmingham:—View of the effluent channel of one of the new sprinkling filter beds. The tile drains are sloped towards this collecting channel.

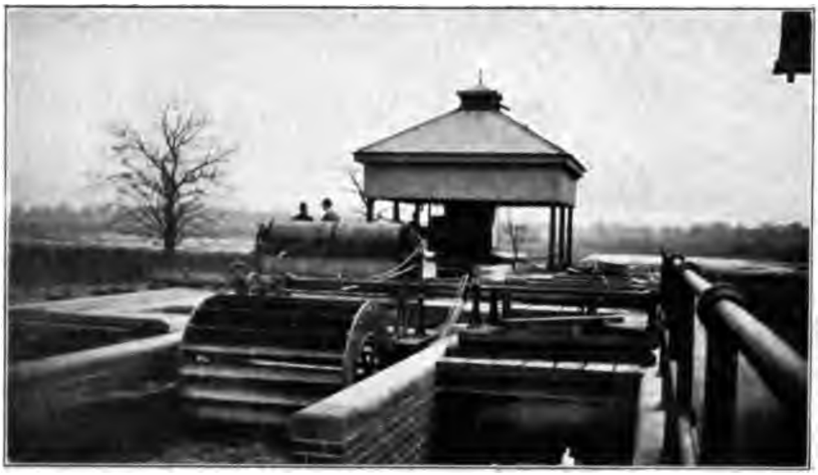


Birmingham:—General view of one of the new sprinkling filters in operation. The nature of the underdrains, the side walls, and the manner of sewage distribution are shown.



Salford :—View of the drainage system of one of the new sprinkling filters under construction. Large pieces of cinder are placed over perforated square tiles. The brick columns used to support the distributing pipes act as ventilators.

Birmingham :—View showing a sprinkling filter in course of construction. The half tile drains are laid side by side.



Birmingham:—View of a revolving inclined screen operated by water power from an undershot wheel placed in the main channel.

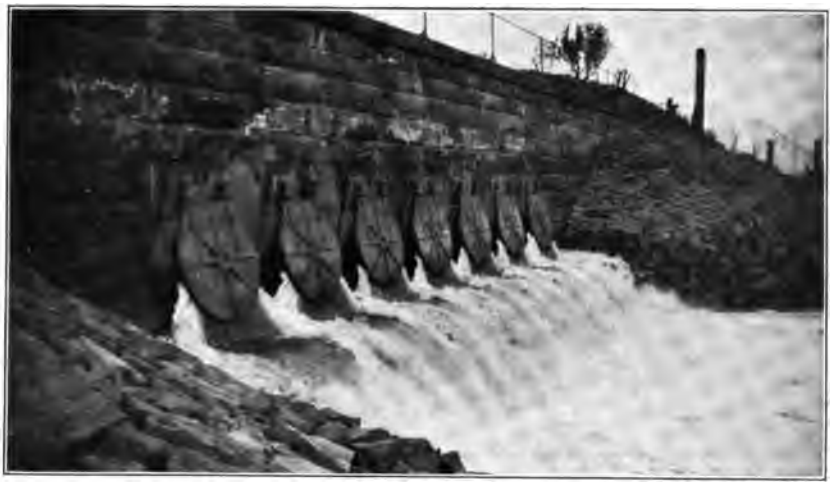
Birmingham:—General view of one of the main channels showing gates.

Glasgow:—View of one of the lime water tanks. The liquid in this tank is agitated by means of stirrers which are made to travel from one end of the tank to the other. The traveler moves over a track and is operated by electricity.

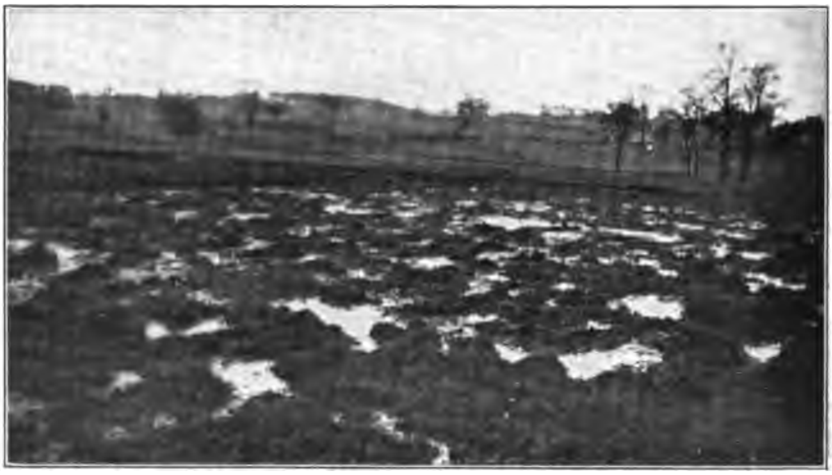
Glasgow:—View of the chemical tanks in which the solution of sulphate of iron is prepared.

Glasgow:—General view of the chemical precipitation tanks.

Glasgow:—View of the lower end of the chemical precipitation tanks showing the effluent channel.



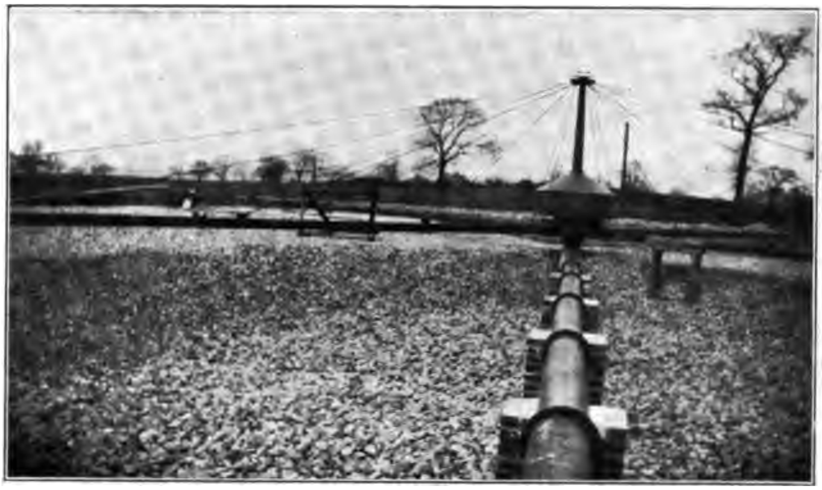
Glasgow:—View of tide gates where the effluent is discharged into the river Clyde.



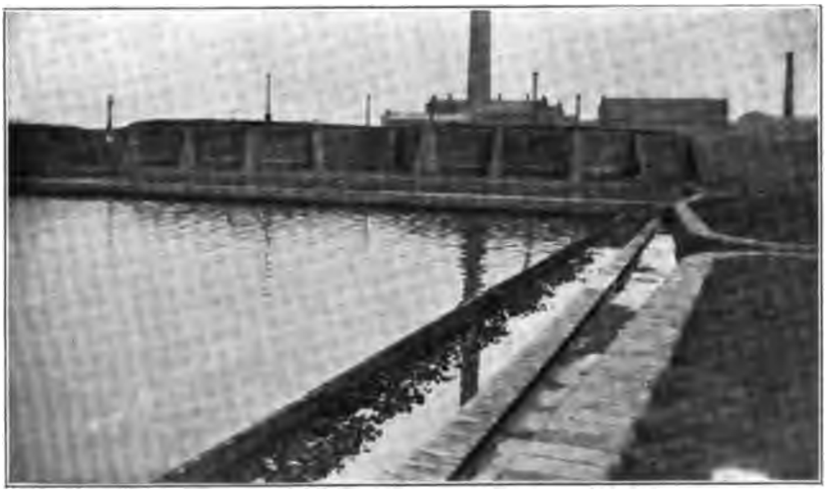
Macclesfield:—Typical view of field receiving sewage. This land has become "sewage sick" on account of being overdosed.

Macclesfield:—View of septic tank showing scum in one corner. Revolving sprinkling filter may be seen in the distance.

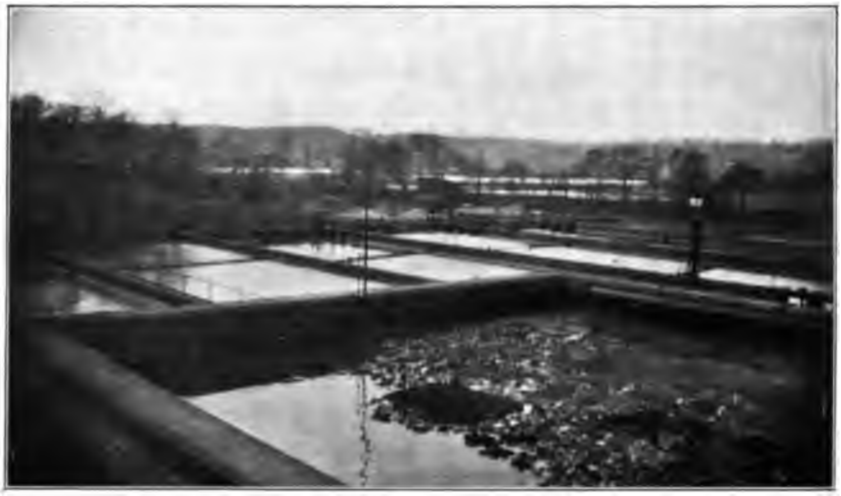
Macclesfield: —View of storm beds showing mode of distributing sewage over the surface.



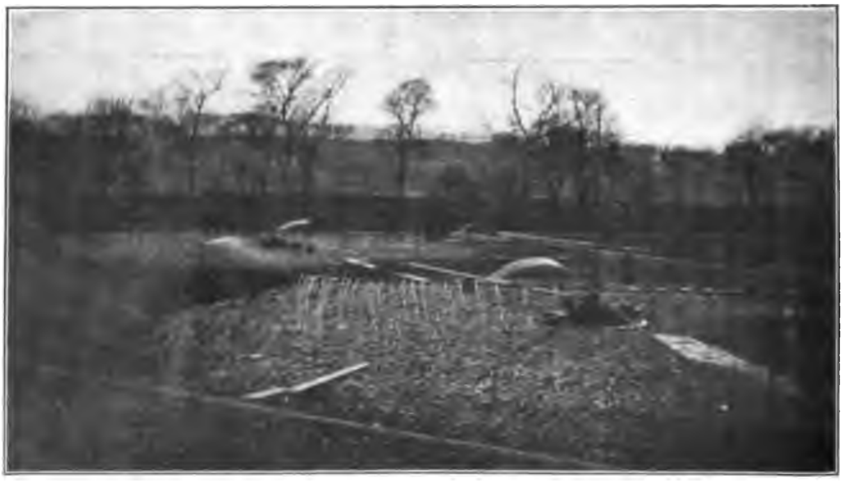
Macclesfield:—Type of revolving sprinkling filter used at Macclesfield. The material is crushed stone.



Hyde:—View showing settling basin and roughing filter for effluent from sprinkling filters. The liquid sewage passes away through the channel to the right. The sprinkling filters are shown in the distance.



Rochdale:—View showing septic tank in the foreground and chemical precipitation tanks beyond. Two sprinkling filters are located between these precipitation tanks and the building shown in the middle of the photograph. The land between these tanks and the river is used for treating the chemical effluent.



Rochdale:—Nearer view of the sprinkling filters shown in the previous photograph. These sprinklers have been in use about seven years, and, with the exception of Accrington, are the oldest sprinkling filters in England. They have never been cleaned and are still giving good results. The effluent is settled before being discharged.

## APPENDIX NO. III.

## REPORT OF MR. H. W. CLARK IN REGARD TO

# SEWAGE PURIFICATION AT PATERSON.

BOSTON, MASS., March 29, 1906.

ALLEN HAZEN, C. E.,
New York City.

Dear Sir:

I make the following report in regard to methods of sewage purification, etc., at Paterson.

**Site and Kind of Filter.** After visiting the city of Paterson and looking at the available sites for filtration areas, etc., I have no hesitation in saying that the most feasible and on the whole satisfactory system of sewage purification that can be adopted by the city is the sprinkling or trickling filter, so called, supplemented by preliminary settling tanks for the treatment of the sewage before going to the filters, and a basin or basins for the sedimentation of suspended matter in the effluents after filtration.

**Depth of Filter.** The deeper that a filter of this kind can be constructed, up to a certain point and allow easy access of air to its interior, the better, other things being equal, will be the degree of purification effected. Studies with such filters have shown that when operated under like conditions with sewage of average strength and at a rate of two and one-half million gallons per acre daily, a non-putrescible effluent can be often obtained when the depth of filtering material is not greater than five or six feet. The margin of safety in this respect is small, however, with such a filter and the degree of purification increases rapidly as the depth of filter is increased. With five or six foot filters, nitrification will be low unless the filtering material is quite fine; but with a filtering depth of nine or ten feet, or more, nitrification will generally be high. In the effluent of the shallow filter, the putrescible organic matter of the sewage will be much less efficiently oxidized than in the effluents of the deeper filters, causing the sediment to resemble to a certain degree sewage sludge, and the effluent will clear itself of suspended matter much less rapidly. Filters eight feet deep will give effluents greatly improved over the effluents of the five or six foot filters, but not equal to the effluents of still deeper filters. Filters nine to ten feet in depth will give effluents containing almost invariably large amounts of dissolved oxygen and an effluent purified to such an extent that it will, when incubated, develop disagreeable odors and the gases of decomposition very slowly. When kept in considerable volumes, exposed to the air, such effluents will improve steadily, and when mixed with equal volumes of river water will, of course, improve with still greater rapidity.

**Filters of Other Construction, etc.**

The only remaining filter to consider in connection with the Paterson problem is the contact filter. Experience with these filters, however, covering a period of nearly ten years, has shown that the rate of operation that can be maintained by them, as ordinarily constructed, is not greater than one-third or one-fourth the rate that can be maintained with sprinkling filters; that even at this rate effluents less satisfactorily purified will be produced; that in order to cause nitrification to occur within them to any great extent they must be constructed of rough materials, such as cinders or coke; that when constructed of broken stone of the grade suitable for the construction of trinkling filters, nitrification is feeble within them and a putrescible effluent generally produced; that they clog rapidly, and it is only a question of time when the entire filtering material has to be removed and washed.

**Storage of Organic Matter.**

Filters of broken stone, operated under my direction as sprinkling filters, at rates approximating two million gallons per acre daily, have in seven years stored within less than 2.5 per cent. of the organic matter applied and about one per cent. of the applied nitrogen, practically enough only to increase their efficiency to a high point.

Contact filters constructed of the same kind and grade of material as the sprinkling filters, and operated at about one-fourth the rate of the sprinkling filters, have stored in three years twenty-four per cent. of the applied organic matter, and nine per cent. of the applied nitrogen. The oxidation in the contact filter compared with the oxidation in the sprinkling filter has been as about 1 to 10. The matters stored for a time in sprinkling filters are, when a certain stage of oxidation is reached, loosened from the filtering material and pass away in the effluent.

**Sediment and Rate of Sedimentation** The sediment in the effluents of deep sprinkling filters settles rapidly, the rate of sedimentation depending to some extent upon the amount present. Generally, however, from 60 to 70 per cent. of the total amount will settle out in two hours. The removal of this matter can be still further effected by the passage of the effluents through upright strainers of fine wire or double sheets of wire with a few inches of coke or coal between. Sedimentation in basins five feet in depth, such as I have experimented with, reduces the suspended matter as stated above, about 70 per cent., and decreases the average turbidity of the filters from about 8 to 10 parts per 100,000 to 2 or 3 parts per 100,000.*

**Chemical Precipitation.** I do not consider chemical precipitation worth considering in the Paterson problem. While the supernatent sewage after treatment with chemicals could undoubtedly be purified by passage through sprinkling filters, the volume of sludge produced would be much greater than produced by the plant previously described, that is, settling basins, trickling filters and sedimentation basins, and the expense for precipitants would be large.

**Volume of Sludge.** At Worcester, Mass., the volume of wet sludge from the chemical precipitation plant averages about 0.6 per cent. of the total volume of sewage treated. At Manchester, England, the volume of wet sludge was, when the sewage was treated chemically, about 0.5 per cent. of the volume of sewage treated. At Paterson, similar results would probably be obtained. If the volume of sewage at Paterson approximated 20,000,000 gallons per day, as seems probable, with chemical precipitation installed there would be in the neighborhood of 120,000 gallons of wet sludge daily. By sludge presses this could be reduced to 120 tons of sludge cake, or 175 yards. By the use of settling tanks, operated perhaps as septic tanks, the sludge accumulating daily would not amount to more than 40 per cent. of the volume from chemical precipitation or 46,000 gallons per day, and might be very much less. This would be more concentrated than the sludge from chemical precipitation, but the weight and volume of the sludge cake, if presses were used, would, volume for volume of sludge, be about the same. I assume, however, it would probably be cheaper to carry the wet sludge out to sea. If the settling tanks were operated as true septic tanks and cleaned out only at considerable intervals, the volume of sludge that would finally remain to be disposed of might not be greater than 0.05 per cent. of the daily flow.

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*For method of determining turbidity, see p. 246, Mass. State Board of Health, Report for 1904.

**Discharge of Effluent and Likelihood of Nuisance.**

You state that the present minimum flow of the Passaic river is several times as great as the prospective volume of sewage effluent, but that there is a likelihood of portions of the watershed being taken in some future time for water supply purposes, thus reducing the minimum flow of the river in the course of a generation to a figure much lower than it now is; that on the other hand there is a possibility of the construction of storage reservoirs for the purpose of increasing the minimum flow. I have already stated that the effluents of deep experimental sprinkling filters are practically nonputrescible and contain much dissolved oxygen. If the effluents of sprinkling filters on a large scale approximated in degree of purification the effluents of such filters as I have experimented with, they could be discharged after the removal of a considerable percentage of their suspended matter without admixture with the river water and cause no nuisance in themselves. Allowing that with a large purification plant the effluents produced would be less satisfactory than the effluents of experimental filters, it is still probable that when freed from a considerable percentage of matters in suspension, they would when mixed with an *equal volume* of *river water* cause no nuisance. If the minimum flow of the river is at all times several times as great as the sewage effluent, there is no possibility of such effluent being a source of offense or causing any nuisance whatsoever. As before stated, the effluents will contain dissolved oxygen; will stand incubation at summer temperature for a series of days without the development of odors and when standing quiet but exposed to the air, will steadily improve in character. When diluted with river water and moved about in the channel by the motion of the tides, there is, I believe, no possibility of a nuisance being caused.

**Size of Settling Tank.**

This tank should be built of such size that it will hold at least eight hours' flow of the average daily volume of sewage. Assuming the volume to be 20,000,000 gallons daily, this would mean a tank of a capacity of about 7,000,000 gallons, or nearly 1,000,000 cubic feet. A tank say 500 feet long, 250 feet wide and 8 feet deep; such a tank could be divided lengthwise into two or more equal compartments. Practically the only advantage in covering it would be the prevention of the escape of odors.

**Area of Filters.** If the beds approximate ten feet in depth, there should be at least one acre of filter area for each 2.5 million gallons of sewage. I see no reason why these beds should have an area of less than one acre each, unless a smaller area would allow of better schemes for ventilation.

**Clarification Tank and Sediment.** The clarification tanks should hold about two hours' flow. The sediment collected in this way will be of a very different nature from sewage sludge. It will be stable on account of being freed from a very large percentage of the original quickly putrescible matter present in the matters in suspension in the sewage reaching the filter, and will have considerable fertilizing value.

**Manufactural Wastes.** The influence of the manufactural wastes upon the purification of the sewage would depend upon the character and volume of these wastes as compared with the volume of the domestic sewage. The principal wastes are from the gas works and from the silk mills. The gas house waste is comparatively small in volume. A considerable purification is now made at the works. Further purification can be obtained by chemical precipitants and small filter beds constructed at the works. Taking into consideration the small volume produced, enough purification could be effected to allow the passage of these wastes directly into the river. The silk wastes, I am not fully informed in regard to as yet. While large in volume, it is probable that a considerable percentage of these wastes is of such a character that they can be discharged directly into the river after perhaps passing through sedimentation basins, screens, etc. The successful treatment of the remainder in connection with the domestic sewage, depends upon the relative volume of waste and sewage. If the volume of sewage is great enough and the organic matter present in it of sufficient amount, the color due to wasted dyestuffs will be destroyed before the sewage reaches the filters. Much of the gummy matters will be retained by the settling tanks and the remainder will be largely destroyed in the filters, judging from experience that I have had with a sewage containing more waste silk liquor than domestic sewage. At this plant, the sewage was often of a pale pink color when reaching the filtration area; it was, moreover, very fresh when reaching this area and passed directly to sand filter beds without passing through settling tanks. This sewage nitrified well in these filters when the surface of the beds was kept in proper condition. Better nitrification was obtained when the sewage was subjected to preliminary treatment. A settling tank removed about 50 per cent. of the organic matter.

**Fatty Matters.** I note your statement in regard to the enormous amounts of soap used. Of course a considerable percentage of this is wasted. Sprinkling filters, however, as shown by experiments that I have made, have a most remarkable fat destroying power and hence the amount of fat present in the sewage is perhaps not of great moment.

Respectfully submitted,

(Signed) H. W. CLARK.

## APPENDIX NO. IV.

### REPORT OF MR. H. W. CLARK IN REGARD TO

# TREATMENT OF WASTE FROM GAS WORKS.

BOSTON, MASS., April 9, 1906.

ALLEN HAZEN, C. E.,
New York City.

Dear Sir:

In regard to the gas waste, the following treatment can be recommended, and will give, I believe, good enough results to allow the treated liquor to run directly into the river. After the waste liquor has passed through the collecting and settling system now installed, it should be treated with lime in the proportion of about 3,000 pounds per million gallons. More may be necessary, and less, perhaps, will do; but that is the average with such gas liquors as I have experimented with. With 60,000 gallons of waste liquor per day this would mean the use of about 200 pounds of lime per day.

After this treatment the liquor would pass into a settling basin holding about three hours' flow; that is, 7,500 gallons, and from this basin it should, if possible, flow through an upright strainer of coke set into the side of the basin, this strainer being simply a wire basket four or five feet long, eighteen inches deep and six or eight inches wide, filled with coke. This coke arrests considerable oil and other floating matter. After this it should pass through a sand or cinder filter; sand seems to have given the best results. This filter can, of course, be small if attended to in good shape. At Lowell, from ten to twenty thousand gallons per day pass through a filter about three feet deep and not over 300 square feet in area.

I am assuming in all this that the liquid now going from the Paterson gas plant is of about the character of a similar waste at Lowell before final treatment. You may find at Paterson that after chemical precipitation the liquid can run directly into the river without filtration. I believe, however, for many reasons that it will be safer to put in the filters.

Very truly yours,

(Signed) H. W. CLARK.

## MEMORANDA REGARDING GAS PLANT OF THE PUBLIC SERVICE CORPORATION OF PATERSON, BY MR. CLARK.

On February 15th, I visited the gas plant of the Public Service Corporation at Paterson, and was shown over the plant by Mr. A. D. Whittaker, Superintendent. All gas made at this plant is water gas, and Mr. Whittaker states that the present average volume is two and one-half million cubic feet per day.

There are five machines in operation, and during the past few months a new house has been built and two or three machines installed, which were operated throughout December and January last. The capacity of this new plant is one and one-half million cubic feet per day. From 10,000 to 12,000 gallons of Texas gas-oil are used per day in making the gas.

The wastes from the machines pass through what are known as seal-pots. These wastes consist of water, light and heavy oils, and tarry matters. From these seal pots the wastes run to a circular tank about six feet in diameter, and from this tank into the first separator. These separators, so called, are simply tanks with baffles across, some of these baffles being for the purpose of preventing the passage of the light oils at the top of the liquid, and some causing the deposition of the heavier matters.

From the first separator the waste liquid passes to a second separator, of four or five compartments, also containing baffles. From one compartment of this separator all waste liquors finally pass directly to the river, this separator being located near the river and the pipe to the river passing through the dike or embankment. From the last compartment, however, the liquor is being pumped a large part of the time to the relief holder. This relief holder, so called, is the crude gas holder; that is, the holder to which the gas is passed before being purified. In this holder much condensation occurs; and, as the gas goes to the holder hot, the tar condenses and runs down the inner portions of the tank into the water seal.

The water from the last compartment of the separator, that is pumped to this relief holder, contains considerable oil which has not been retained in the separator chambers, and this oil is taken up to a considerable extent by the gas in the holder. From all the compartments of the main separator, however, the tar is being pumped to the tar receiver, or tanks, near the refuse holder. The tar is first pumped into the upper compartment of this tank, and then largely passes into the lower or underground tank. From this, the supernatent water, containing some oil and tar, passes into the relief holder. From this relief holder a stream of water is constantly passing back again into the main separator, here passing through the various compartments, and then into the river.

The pumping from the main separator is through pipes entering the liquid at different levels, those going to the bottom of the various chambers pumping the tar to the tar tanks, while the pipes in the upper compartment are pumping lighter liquids to the relief holder.

From 1,500 to 2,000 gallons of tar are saved in this way and are burned each day under the boilers, one boiler being erected to burn tar only, and the other two tar that is shot in onto the coal.

Mr. Whittaker estimates that the amount of waste liquor passing into the river is from 30,000 to 40,000 gallons per day. This waste liquor contains considerable of the tarry matters at times, and also those oils which neither sink to the bottom of the separators and become held by the tar, nor those that become retained and skimmed by the baffles.

On the day of my visit no liquid was passing to the river; but judging from the supernatent liquid in the last compartment of the separator, it is a heavy liquid, with strong odors of tar, oil and gas —a liquid probably that has at least 2,000 parts solid per 100,000 parts, judging from its appearance and experience with such liquids.

The gas from the crude gas-holder is passed through purifiers the purifying material being oxide of iron, which is largely made at the plant. The waste oxide of iron, amounting to about 10,000 bushels per year, according to Mr. Whittaker's statement, is used in filling low land. The tar coming from these purifiers is collected in a small tar-tank in the purifying house, and is passed to the separators.

Some of the rain-water from the roofs, yard, etc., goes directly into the river, some through the separators, and some by special drains to the river. Besides the wastes from the manufacturing process there is a six-inch pipe entering the river, through which passes all the wastes from the water-closets, steam blow-offs and elevator. At the new plant (not now in operation) the waste from the blow-offs passes directly to the river in a separate pipe.

A sketch showing the tar separators accompanies these memoranda.

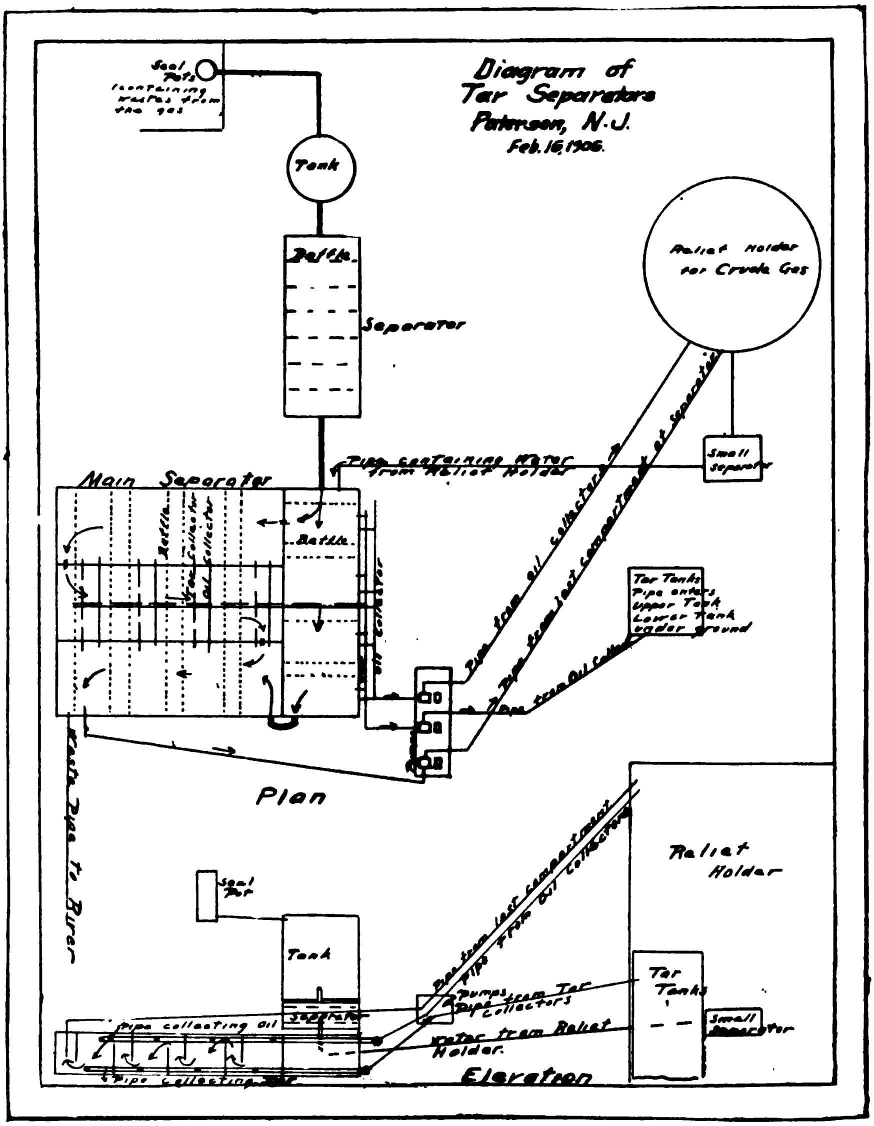

Diagram of
Tar Separators
Paterson, N.J.
Feb. 16, 1906.

APPENDIX NO. V.

# PARTIAL LIST OF SEPTIC TANKS IN USE IN THE UNITED STATES.

| Place. | Population in 1900. | Capacity of septic tank in gallons. | Reference. |
|---|---|---|---|
| Bedford, Ind. | 6,116 | 85,000 | Eng. Record ; XLVI, 465 |
| Burlington, N. J., | 7,392 | 120,000 | Tr. Am. Soc. C. E.; LIV-E ; 157 |
| Centerville, Ia., | 5,256 | 60,000 | Eng. Record ; LIII ; 405 |
| Champaign, Ill., | 9,098 | 22,200 | Eng. News ; XLII ; 111 |
| Charlotte, N. C., | 18,091 | | Eng. Record ; LI ; 711 |
| Collingwood, N. J., | 1,633 | | Eng. Record ; XLV ; 416 |
| Danville, Ky., | 4,285 | | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Dekalb, Ill., | 5,904 | 60,000 | Eng. News ; XLVIII ; 460 |
| Depew, N. Y., | 3,379 | 95,000 | Eng. News ; XLVII ; 514 |
| Downers Grove, Ill., | 2,103 | 64,000 | Eng. Record ; LVIII ; 127 |
| Durham, N. C., | 6,679 | 250,000 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| East Cleveland, Ohio, | 2,757 | 170,000 | Jour. Assoc, E. S. ; II ; 266 |
| Fondulac, Wis., | 15,110 | 371,400 | Eng. News ; XLVII ; 410 |
| Gardner, Mass., | 10,813 | | |
| Glencoe, Ill., | 1,020 | | Eng. News ; XLVI ; 313 |
| Greensboro, N. C., | 10,035 | | Eng. Record ; L ; 687 |
| Grinell, Iowa, | 3,860 | 225,000 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Highland Park, Ill., | 2,806 | | Eng. News ; XLVIII ; 460 |
| Holland, Mich., | 7,790 | 64,000 | Eng. Record ; XLIII ; 247 |
| Hopedale, Mass., | 2,087 | | |
| Independence, Mo., | 6,974 | 262,000 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Iola, Kas., | 5,791 | 168,000 | do |
| Kenton, Ohio, | 6,852 | 21,000 | Jour. Assoc. E. S. ; XXXII ; 268 |
| Kewanee, Ill., | 8,382 | 450,000 | Tr. Am. Soc. C. E. ; LIV-E. ; 157 |
| Kingston, N. Y., | 24,535 | | do |
| Lagrange, Ill., | 3,969 | 200,000 | Eng. Record ; XLVII ; 200 |
| Lake Forest, Ill., | 2,215 | 50,000 | Eng. News ; XLVIII ; 460 |
| Liberty, N. Y., | 1,760 | | Eng. Record ; XLII ; 146 |
| Macomb, Ill., | 5,375 | | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Madison, Wis., | 19,164 | 400,000 | Eng. News ; XLVI ; 287 |
| Mansfield, Ohio, | 17,640 | 1,000,000 | Jour. Asso. C. E. ; XXXII ; 268 |
| Marion, Ohio, | 11,862 | 390,000 | Eng. News ; LV ; 197 |
| Marion, Iowa, | 4,102 | 150,000 | Eng. Record ; XLIII ; 323 |
| Monmouth, Ill., | 7,460 | 400,000 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Muscogee, I. T., | 4,254 | 50,000 | do |
| Plainfield, N. J., | 15,369 | 450,000 | Eng. Record ; XLIV ; 471 |
| Pomona, Cal., | 5,526 | 27,500 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Princeton, Ill., | 4,023 | 60,000 | Eng. News ; XLVIII ; 460 |
| Red Bank, N. J., | 5,428 | 100,000 | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| San Luis Obispo, Cal., | 3,021 | 52,000 | do |
| Santa Rosa, Cal., | 6,673 | 310,000 | do |
| SaratogaSprings,N.Y. | 12,409 | 1,000,000 | Eng. Record ; LI ; 82 |
| Urbana, Ill., | 5,728 | | Tr. Am. Soc. C. E. ; LIV-E ; 157 |
| Wauwautosa, Wis., | 2,842 | 160,000 | Eng. News ; XLVIII ; 460 |
| West Allis, Wis., | 3,500 | 80,000 | Eng. Record ; XLIX ; 183 |

## APPENDIX NO. VI.

## MEMORANDA FROM MR. H. W. CLARK IN REGARD TO

# ODORS OF SEPTIC SEWAGE OR SEPTIC TANKS.

The use of septic tanks in connection with sewage disposal works was a subject for discussion at the meeting of the Sanitary Section of the Boston Society of Civil Engineers, held February 3, 1904, and the papers and discussions are published in the Journal of the Association of Engineering Societies, Vol. XXXII, January to June, 1904, pages 251 to 291.

Frank A. Barbour makes no comment on odors.

Harrison P. Eddy, Worcester, Mass., says (page 259) :

The sludge from the septic tank is a very characteristic material. It is black, usually finely divided, rather heavy and of an extremely offensive odor, unless it has been allowed to undergo very complete decomposition. To run it onto land in its natural wet condition would made an intolerable nuisance if there were any dwellings nearby or if the plant was near a frequented road. It can be reduced in volume by filter pressing only with great difficulty and at very excessive cost.

Andrew J. Gavett, Plainfield, N. J., says, (page 264) :

The sludge accumulates very slowly on the bottom of the tanks, but the scum gathers more rapidly, and is removed, about three times a year, through the sludge pipes to a sand filter bed, after as much as possible of the clearer middle water has been run off onto other beds, separate valves and pipes being provided for this purpose. When the sludge is running from the tanks a deodorant is added, either strong limewater or permanganate of potash, the latter being preferred.

R. Winthrop Pratt, Engineer Ohio State Board of Health, makes first a general statement and then refers to various septic tanks in Ohio. His general statement is (page 266) :

The odor from the tanks is often no more objectionable, if it is as much so, than that from the average settling tank, but in some cases very offensive odors are created.

With reference to the East Cleveland tank, he says (page 267) :

The odor from the septic sewage, as it flows onto the filters, combined with the odor from the clogged filtering material, is offensive, and causes more or less complaint on the part of the nearest resident.

With reference to the Kenton tank, he says, (page 268) :

Very little odor can be noticed around the plant, and I found, upon entering the house over the tank, after it had been locked for several weeks, that the odor inside was not the least offensive ; in fact it was much less than that arising from any settling tank that I can recall.

Regarding the Mansfield tank, he says, (page 269):

The plant is well removed from any dwellings, and the septic tank is ventilated into the stack at the pumping station. There is no objectionable odor around the plant. One of the tanks, after one and one-half years' use, was drawn off and only a few inches of deposit found in the bottom. No surface scum has formed to any extent in any of these tanks.

Regarding the tank at the Soldiers' and Sailors' Home, Sandusky, he says (page 270):

The tank has been in operation some eight or nine months. A heavy scum of a foot or more has formed at the surface and there is more or less of a deposit at the bottom. The tanks have not been cleaned, however. At the beginning both tanks were used but then septic effluent proved to be so offensive that it was objectionable to the occupants of houses 600 to 1,000 feet distant. One of the tanks, therefore, was cut out of the service, and since then the odor of the septic sewage has been less objectionable.

With reference to the tank at the Trumbull County Infirmary, he says,(page 270):

During its four and one-half years of operation this septic tank has been cleaned but once. The sludge in the bottom retains a constant depth of about one foot and the scum is three or four inches thick. The long septic period and subsequent storage in the reservoir do not seem to prevent satisfactory purification.

The odor is very strong, but is largely confined to the small wooden pump house over the tanks, which is ventilated into the stack at the boiler house. The iron of the pump has been attacked by gases from the tank. The system of ventilation, however, enables the tank to be located near the institution buildings without causing a nuisance.

X. H. Goodnough, Chief Engineer Massachusetts State Board of Health, says (page 273):

The experiments upon the purification of septic tank effluents have not given such favorable results as are obtained in actual practice by intermittent filtration.

Dr. Douglas C. Moriarta, Saratoga Springs, N. Y., says (page 275):

Concerning the value of sedimentation or retention in the tanks, I hardly know what to say after listening to the remarks of your experts on this subject; because our plant has only been in operation since July, and thus far we have had no occasion to empty it, nor are we annoyed in any way from it, and our chemist informs us that we are having a marked liquefaction of the sludge. At the aerator there is a slight odor, but not at all marked, and when the sewage is on the beds it is even less. In the immediate neighborhood are two residences; thus far we have had no complaints. If we ever have to empty our retention tanks, and it acts as those described by the authors of your interesting papers, we will probably have something to say on this subject when we meet again.

Harry W. Clark, Chemist Massachusetts State Board of Health, on page 278, makes the following statement:

During the past year a septic tank, known as Septic Tank E, has been in operation at Lawrence; it seemed to us, owing to many published reports in regard to the large amount of organic matter removed by the operation of some septic tanks, that the character of the water supply in these different localities, or the ground water entering the sewers, might have some effect upon this removal. That is, we thought that where a particularly hard water was in use, or hard water entered the sewers, a species of chemical precipitation might occur in the tank, owing to the passing out of solution of some of the mineral salts, causing the hardness, while the sewage was undergoing tank action. Therefore the sewage entering this septic tank was made very hard by the addition of such mineral salts as we find in hard waters—lime, magnesia, chlorides, etc. While some such action as we expected occurred, the principal result from this tank was to explain in a way the difference in the character or strength of the odor of septic tank effluents. For instance, the effluent from our Septic Tank A at Lawrence, while always having a considerable odor, is not particularly offensive. The effluent of this tank, however, was exceedingly offensive, and was caused by the generation or liberation of sulphuretted hydrogen from the sewage, this being due to the decomposition of the sulphates added to make the sewage hard. The gases set free from Septic Tank A upon analysis have never shown any sulphuretted hydrogen, but there was a large amount in the effluent of this tank. You have all read, of course, of the disputes as to whether septic sewage is ill-smelling or not, and naturally, no doubt, it varies much at different places, due to some such local reason as this experiment might indicate. Mr. Cameron, in the testimony already referred to, stated that in his opinion the difference was due to time of passage, but this cannot, I believe, account for all discrepancies on the odor discussion.

F. Herbert Snow, says, (page 290):

The speaker wishes to record his testimony at this time as against the policy of the general adoption of the modern septic tank. The tank of the day is more than likely to cause a more serious nuisance in the neighborhood of the installation, unless extreme precautions are adopted. The disposal of the insoluble mineral sludge, together with more or less organic matter, is a most difficult problem, and in every case the speaker knows about is accompanied by offensive odors.

Whether these difficulties are inherent in the process, or may be eliminated by the attention to details of design and operation, remains yet to be demonstrated.

The expense of doing this, if it can be done, is a factor for consideration, and also the important fact that the process is on the wrong side of the sanitary fence, anyway.

Still further, if the chemical changes in the liquid of any particular case is likely to render the sewage more difficult to purify, there is an added doubt as to the advisability of the adoption of the process.

So far as the speaker is able to judge at the present time, from his lifetime experience and observation, the staling of sewage in settling tank, disposal of solids while in a comparatively fresh state, and in small quantities, and the oxidation of the supernatent liquid by one of the several approved methods, is the safest and very best system for general adoption.

In the Journal of the Association of Engineering Societies, Vol. XXVIII, 1902, page 325, Prof. Kinnicutt makes the following statement:

As to the odor from a septic tank, some say it is very offensive, others that it is hardly noticeable. Both are right. In England I have seen many tanks which gave off the most offensive odors and others which gave off very little odor. Why this is so we do not know, nor can it be told before hand whether a certain sewage will or will not give off offensive odors while septic action is taking place. At the present time I believe if tanks are to be erected near dwelling houses or frequently traveled roads the only safe rule is to build closed tanks.

The Engineering Record of November 18, 1905, pages 574-577, contains a well-written paper on Tankage of Sewage, by F. Wallace Stoddart. It calls attention to the difference in results in different places, particularly in the production of offensive odors, and after tabulating the results in various places, concludes that the most variable factor is the length of time occupied by the treatment and the degree of putridity attained by the sewage. Further attention is called to the unsatisfactory results as regards odor and subsequent filtration when the sewage is detained too long. He quoted an instance where, with a dry-weather flow of 3,000 gallons, storage capacity of 14,000 gallons was provided, with a result that the whole contents of the tank were black as ink and the offense to the neighborhood was intolerable.

He suggests the provision of one cubic foot of storage for every six and one-quarter gallons of dry-weather discharge per day. He also suggests that the tank can be made somewhat larger to advantage.

Mr. Johnson, Principal Assistant Engineer, State Board of Health, says that the Gardner septic tank was not offensive, but that the sludge was let out when he was there and it was so extremely offensive that the odor remained with him several days.

At Hopedale, also, the septic tank is not offensive, but he made no remark about the sludge, and I think he had not been there when the tank was cleaned out.

The Andover sewage was septic and offensive.

The Boston sewage contains sulphuretted hydrogen, which is probably caused from the salt-water entering the sewers.

In the discussion of sewage disposal at the Engineering Congress at St. Louis, (Vol. LIV, Part E), Mr. G. W. Fuller makes the following statement, (page 183):

> The odors in the neighborhood of septic tanks are usually noticeable at some little distance, although ordinarily they are not seriously objectionable even at the tanks themselves. With some kinds of sewage, however, this is not the case. In general, bad odors result from the septic treatment of those sewages containing relatively high amounts of sulphur compounds, such as the acid sewage at Worcester. A similar result is possible, in less degree, with the sewage from communities in which the water is hard, due to sulphates of lime and magnesia. Where sulphate contents are fairly low these odors, perhaps somewhat allied to sulphuretted hydrogen, are generally not so conspicuous.

Prof. Van Ornum, referring to a very small septic tank at Washington University, says (page 208):

> Contrary to the statement in the paper concerning the usual odors, no odor is perceptible outside this septic tank, and but very little inside it.

Mr. Hooper, of the Local Government Board, London, England, after discussing the various methods of sewage disposal in England and the requirements of the Board, says, (page 233):

> Nuisances arising from Sewage Disposal Works:—These may be said to be practically nil, except in the case of insufficient attention on the part of employees, and the

fact that many hospitals, asylums, recreation grounds, etc., often adjoin the works without any bad effects is sufficient to prove that they are not necessarily dangerous neighbors.

Mr. Killon, of Manchester, England, makes a statement with regard to sprinkling filters, and says :

A new type of automatic revolving sprinkler, by which uniformity of distribution over every square foot, to within 10 per cent. of the mean delivery, is now effected without the offensive spraying due to fixed jets or the difficulties incident to the use of revolving distributors of the Barker's Mill or Reaction Wheel type.

N. N. Baker makes several notes about septic tanks in his book on British Sewage Works. In connection with Sutton he says (p. 18) :

The tanks are cleaned only once in twelve months, when the sludge and scum together usually have a depth of 3½ feet. The sludge is discharged by gravity into a lagoon, and, according to Mr. Dibden, is the cause of considerable nuisance when it is left to drain and dry.

At Birmingham (page 79) he says :

The septic tanks were used for about 3½ years without having any sludge removed. After pumping off the liquid above the sludge the latter was pumped to a large bed in January, 1904, where it still remained in April, 1904. As soon as dry weather arrived Mr. Watson proposed to plow it in and sow a crop on the land. About 60 per cent. of the septic tank sludge (dried sludge) was inorganic matter and had no more smell than ordinary garden mold.

There is also a note with reference to intermittent filtration at Birmingham (page 85) :

Mr. Watson states intermittent filtration areas are essentially offensive to the eye, and sometimes to the nose.

Covered carriers have also been used of late, both to maintain the temperature of the sewage and to keep up the hydrolytic action begun in the septic tanks. A third reason for covered carriers, which to some extent arises out of the second, is to keep down smell.

I visited the sewage farm and works on a cool, windy day, after rainy weather. No odor was noticed, except a slight one where the septic tank effluent was rushing into the main carrier. Some of the intermittent filtration area, which had been used through the winter, was covered in depressed sections with sludge and green slime, thus bearing out the statement by Mr. Watson, quoted a few lines back.

In the Columbus report (page 123) :

Absence of Odor.—At no time, even during the period of warm weather, near the end of the tests, were offensive odors noted about any of the septic tanks, a feature which was frequently commented on by visitors. When the tanks were cleaned in June at the end of the tests, it was remarkable how little odor emanated from the sludge layer as it was flushed from the tank. At that time, such odors as did arise could not be detected at a distance of 100 yards.

Mr. G. W. Fuller, in his statement made in Baltimore, March 15, 1906, makes the following statement with regard to Birmingham (p. 16.) :

Mr. Watson says the most important thing he has done on the sewage question is to demonstrate that the sewage containing some trade waste, and that almost entirely composed of pickling liquor, he can take the sludge from septic tanks and apply it to land and have no trouble whatever with odors.

The sludge is an innocuous humus mass; it looks somewhat like a mixture of India ink and mucilage. There is very little odor to the sludge and nothing objectionable around the tanks. You could get a hundred yards away and not know you were near it. In fact, some of the land he is using for sludge purposes is divided only by a railroad track from the grounds of the Castle Bromwich Race Track. He is also applying sludge from the septic tanks to land within less than ⅛ of a mile to his own residence

There is an instructive article on the disposal of sewage sludge at Saltley, England, in the Engineering Record, of November 5, 1904, page 544. It is a three-page article and relates to the disposal of sludge from chemical precipitation roughing tanks, etc., and in many cases there was a very strong odor. There is, however, the following statement with regard to the septic sludge from the finishing tanks, after long septic action:

The septic residuum was deposited on land in a layer of about 15 inches deep. It gave rise to no offence, no smell has been detected arising therefrom, and after lying open and exposed to the action of the atmosphere for six months and being ploughed over, it would be difficult now to differentiate between the appearance and characteristics of natural surface soil and this material.

## APPENDIX NO. VII.

### Detailed Schedule of Estimate of Cost of

# CONSTRUCTION AND OPERATION OF SEPARATE SEWAGE PURIFICATION WORKS.

| | | |
|---|---|---|
| Intercepting Sewer. | | |
| Intercepting sewer to foot of Market street, as per detailed schedule Appendix XXII | | $ 724,900 |
| Pumping Station. | | |
| Lift, 42 feet; 5 units, each unit 103 water horse power, or 515 in all; @ $500 per water horse power | | 255,000 |
| This figure is based upon the costs of the Metropolitan Sewerage Pumping stations at Boston, and upon experience with water pumping stations. The cost is a little more than is usual for water pumping stations, because of the extra cost of the screens and sewage chamber, which is included in this item. | | |
| Rising Main. | | |
| 60-inch rising main, from pumping station to purification works, including river crossing, 6300 feet | | 103,000 |
| Settling Tanks. | | |
| The estimates for main settling tanks are based upon preliminary sketches, and similar experience in building reservoirs for this and other purposes, and are estimated at $10,000 per million gallons: Capacity, 20 mil. gals | | 200,000 |
| | | $1,282,900 |
| Sprinkling Filters, 12 acres. | | |
| Trap rock, broken and washed, 193,000 cu. yds. @ $1.75 | $338,000 | |
| Concrete bottom and drains, average thickness 9 inches; 14,500 cu. yds. @ $7 | 102,000 | |
| Pipe lines, 15 feet apart, with specials 36,000 feet, @ $1.25 | 45,000 | |
| 2,020 risers, each 10 feet long, @ $2 | 4,000 | |

| | | |
|---|---|---|
| 2,020 sprinklers, @ 50c. | 1,000 | |
| Floor drainage tile, about 9c. per sq. ft. | 42,000 | |
| Excavation, average depth 6 feet; 117,000 cu. yds. @ 40c. | 47,000 | |
| Gates, 200 @ $15. | 3,000 | |
| 48 inches steel pipe and connections, 1,000 ft. @ $15. | 15,000 | |
| Passageways and wasted drains, 1,000 ft. @ $12. | 12,000 | |
| Estimated cost of 12 acres sprinkling filters. | $609,000 | |

Estimated cost per acre, $50,750.

The above estimate is for filters which it would be necessary to install at once, and for the ultimate needs 20 acres would be necessary.

| | |
|---|---|
| 20 acres of sprinkling filters, @ $50,000 per acre. | $1,000,000 |

### FINAL EFFLUENT TANKS.

| | |
|---|---|
| Capacity, 5 million gallons, @ $10,000. | 50,000 |

The final settling tanks are estimated in the same way as the main settling tanks, namely, on preliminary sketches and similar experience in building reservoirs for this and other purposes.

### SLUDGE TANKS.

The sludge tanks are estimated at $8 per cubic yard of capacity, being about the cost of the elevated sand bins for Washington, D. C., filtration plant. A slight reduction is made because of the smaller specific gravity of the sludge as compared with the weight and sand.

This design was suggested with the idea that the sludge would be pumped to these tanks and the supernatent liquor in them would run back to the effluent tanks by gravity, and carts or cars could be run under the tanks and take the sludge from them without handling. It may be that some other type would be advantageous, however. The price per cubic yard includes all appliances complete for economical emptying.

| | |
|---|---|
| Sludge tanks, 10,000 cu. yds. capacity @ $8. | 80,000 |

| | |
|---|---|
| POWER HOUSE. | |
| Power house and equipment for handling sludge, pumping back flushing waters, etc. | 50,000 |
| OUTLET FROM WORKS. | |
| 72 inch outlet from purification works to Passaic river, about 4,500 feet. | 90,000 |
| Land, right of way, draining, roads, etc | 200,000 |
| | $2,752,900 |
| Engineering and contingencies, 10 per cent. | 275,290 |
| Total cost of purification works suitable for treatment of sewage from an ultimate population of 250,000 | $3,028,190 |

## COST OF OPERATING SEWAGE PURIFICATION WORKS, FOR A POPULATION OF 250,000.

| | |
|---|---|
| Average daily flow of sewage, @ 125 gallons per capita | 31 million gallons |
| Average flow per annum | 11,300 million gallons |
| Removing 10 cubic yards of sludge per million gallons from final effluent tanks and pumping it to septic sludge tanks @ 20c. per cubic yard, $2 per million gallons | $22,500 |
| 5 cubic yards per million gallons taken from septic sludge tanks and spread on land, @ 35c. per cubic yard, $1.75 per million gallons | 20,000 |
| Care of grounds, sprinklers and superintendence, @ $1.25 per million gallons | 14,000 |
| Care of filtering material; washing one-tenth of filtering material annually | 19,000 |
| Total annual cost of operation | $75,500 |
| Total annual cost per capita | $0.30 |
| Care and inspection of intercepting sewer, and of pumping sewage | 0.18 |
| Cost of removing storm water | 0.10 |
| Cost of operation per capita | $0.58 |
| Capital charges; 5 per cent on average investment of $16 per capita | 0.80 |
| Total annual cost per capita, including capital charges, of operating sewage purification works | $1.38 |

## APPENDIX NO. VIII.

## Report of Weston E. Fuller,

# ON SIZE, SLOPE, DRAINAGE AREAS AND CAPACITIES OF PATERSON SEWERS.

According to your instructions of February 26th and March 9th, I have examined the Paterson sewers in regard to drainage areas and capacities, and have made gaugings of the flow in the sewers.

**Drainage Areas.** I obtained from the City Engineer, Mr. Harder, a map of the city showing contours, sewers and drainage areas. The sewers and drainage areas were drawn on from old reports. In many cases either the one or the other is obviously incorrect, as the sewers cross the drainage area boundaries. The areas are identical with those given in the Wise-Watson-Ferguson report, and are evidently taken from the same source. In many cases these areas include several outlets.

Aided by Mr. Harder's advice I have been over this map and have laid off what we consider the most probable area for each outlet. In doing this we laid off the present area drained by the sewers, as well as the ultimate area. These areas are shown on the maps accompanying this report. There are without doubt errors in these areas, but I think that they are mostly of small amount and that the area as given is approximately correct.

We have included in the ultimate area of each sewer the entire area that naturally drains to that sewer. In many cases part of this area could quite as well be drained by other sewers, either by those now built or by those which will be built in the future as the the area develops.

The drainage areas as we finally determined them are given in the table appended hereto. A summary of these areas is as follows:

| | |
|---|---|
| Total present drainage area of sewers | 2,752 acres |
| Total ultimate drainage area of sewers now built | 4,116 acres |
| Area draining directly to river, for which no sewers are needed | 230 |
| Area which can best be cared for by other sewers to be constructed, as the area develops | 814 |
| Total drainage area of city | 5,160 acres |

**Capacities of Sewers.** No data were obtainable as to the slopes of the sewers. The sizes of the sewers are shown on Mr. Harder's map, but are in many cases incorrect. It was therefore necessary to take grades and measurements on the sewers. In general no attempt was made to carry this work beyond the point where the first reduction in size was found. The data here given therefore refer only to the outlets of the sewers.

From our casual inspection it is clear that, in some cases, where the outlet is adequate for storm water, some of the main branches are inadequate. To determine finally whether or not the sewer is adequate for storm water purposes it would be necessary to make a complete survey of the sewerage system.

This work was started on March 13th, at which time I was aided by one of Mr. Harder's assistants. After one day's work we were interrupted by snow, and were unable to continue until March 29th. At that time Mr. Harder was unable to furnish an assistant, and the work was completed with men from this office.

We were much hampered on this work by the difficulty in locating manholes. In many cases on macadamized streets the manholes are completely covered over and cannot be located at all. In other cases they were only found after much difficulty. Some of the manholes on paved streets were cemented in, not having been opened since the pavement was laid. The sewers are not properly flushed, and in many cases apparently no flushing is done. As a consequence many of the sewers have several inches, and some a foot or more of sediment.

The outlets of many of the sewers, particularly in the upper section of the city, were below the river level and the sewers were flooded. This fact, together with the sediment, made it difficult to obtain accurate measurements. Wherever we were unable to get accurate measurements we have taken the sewer as having the section given on the sheet of standard sections furnished by Mr. Harder. These sections are, I think, generally used for sewers forty-eight inches in diameter and below. Above forty-eight inches the sewers are in some cases circular. It is quite probable that some of the sewers that we have considered as egg-shaped are actually circular and have a larger capacity than we have given them. Generally we could get the length of the sewer quite accurately.

It should be noted that the egg-shaped sewers are rated in terms of circular sewers of equivalent areas. That is, a 30-inch egg-shaped sewer is a sewer of sectional area equal to that of a 30-inch circular sewer.

A summary of the computations for the capacities of the sewers is given in the table appended hereto.

## NOTES ON SEWERS.

**Prospect Street.** This sewer is deep and the manholes are without ladders. The main outlet seems to be a 54-inch egg-shaped sewer. The drainage area is mainly thickly populated and the streets are paved to a large extent. The sewer appears adequate for storm-water for the present drainage area. The greater part of the undrained portion of the ultimate area can quite as well be cared for in the future by a sewer having the outfall higher up the river.

**Mulberry Street.** This is an 18-inch tile sewer and is adequate for its ultimate area.

**West Street.** This is an 18-inch tile sewer and is adequate for its ultimate area.

**Bank Street.** This is a 24-inch outlet and is adequate for the ultimate area.

**Main Street.** This is an 18-inch tile sewer. The drainage area is in the business section and the streets are paved. The sewer is entirely too small for storm water.

**Bridge Street.** This sewer has a large outfall to River street. At that street it has three smaller sewers entering it. As the sewer was flooded with water the exact arrangement could not be determined. The outfall is apparently much in excess of the branch sewers.

**Montgomery Street.** This is a twin sewer outlet, each 54-inch, circular for about 800 feet from the river. Beyond that on Paterson street it is a 72-inch circular sewer. The area drained is thickly populated and many of the streets are paved. The sewer is inadequate for storm water. There is some sediment.

**Straight Street.** This sewer is 36-inch, egg-shaped. The slope is very small. The area is thickly populated. The sewer is entirely inadequate for storm-water. There is much sediment.

**Franklin Street.** This is a 12-inch circular sewer and is adequate for storm-water.

**Keen Street.** This is a 15-inch circular sewer. The area is thickly populated. The sewer is inadequate for storm-water.

**Warren Street.** This is a 30-inch egg-shaped sewer. The area is quite thickly populated. The sewer seems adequate for the storm-water from the present area. The ultimate area can as well be diverted to other sewers.

**Lowe Street.** No manholes or outlet could be found.

**Wood Street.** No manholes or outlet could be found.

**East Fifth Street.** This is a 24-inch circular private sewer from Auger & Simon's mill. At the last manhole an 18-inch outlet from the mill is nearly clogged. The water comes out at this point under considerable pressure.

**East Eleventh Street.** This is a 36-inch egg-shaped sewer. No manholes could be located for a distance of 1400 feet from the outlet. The population is not large but there are a number of mills. There is some sediment in this sewer. The sewer is rather small for storm water from the present area. The data on this sewer is indefinite.

**Fourth Avenue.** This is a 30-inch egg-shaped sewer. It is clearly not adequate for storm water from the present drainage area. The sewer is over half full of sediment at some places.

**Second Avenue.** This is a 30-inch, egg-shaped sewer. The area is not thickly populated. The sewer is adequate for the present area under present conditions. There is much sediment.

**Third Avenue.** This sewer is a 30-inch, egg-shaped sewer. It is inadequate for the present area. There are several inches of sediment.

**Thirty-third Street.** We could locate no manholes for a distance of 1900 feet from the outlet. The first manhole that we were able to get up was on the branch sewer on Broadway. It is probable that the main sewer is a 60-inch, egg-shaped sewer. The area is quite thickly populated. The data is not definite, but it seems that this sewer should be adequate for storm-water from the present area.

**Twentieth Avenue.** This is a 42-inch, egg-shaped sewer. It is adequate for storm-water for present area, and for some increase. The remainder of the ultimate area can be cared for quite as well by other sewers.

**Market Street.** This is a 96-inch circular sewer. It is adequate for storm-water from present area and a considerable increase. The present area is, however, almost entirely carried by the Vreeland avenue branch. This branch is adequate for the present area.

**Hamburg Avenue.** This sewer is a 72-inch circular sewer. It is adequate for the storm-water from its ultimate area.

**North Main Street.** This is a 30-inch egg-shaped sewer. It is adequate for storm water from the ultimate area.

**Arch Street.** This is a 30-inch egg-shaped sewer. It is rather inadequate for the storm water. There is a good deal of sediment.

**Jefferson Street.** This is a 24-inch egg-shaped sewer. It is inadequate for storm-water. There is much sediment.

**North Straight Street.** This is a 36-inch egg-shaped sewer. It is rather small for the present area and is inadequate for the storm-water from the ultimate area.

**Bergen Street.** This is an 18-inch sewer, circular, and is adequate for storm water from the present area.

**Short Street.** We were unable to locate any manhole on this sewer.

## SUMMARY.

| Sewers that are adequate for storm water from their ultimate drainage area. | Sewers that are adequate for storm water from their present drainage area. | Sewers that are inadequate for storm water from present drainage area. |
|---|---|---|
| Mulberry Street, | Prospect Street, | Main Street, |
| West Street, | Warren Street, | Montgomery Street, |
| Bank Street, | Thirty-third Street, | Straight Street, |
| East Fifth Street, | Twentieth Avenue. | Keen Street, |
| Second Avenue | | East Eleventh Street,* |
| Franklin Street, | | Fourth Avenue* |
| Market Street, | | Third Avenue* |
| Hamburgh Avenue, | | Arch Street* |
| North Main Street, | | Jefferson street, |
| Bergen Street. | | No. Straight Street.* |

In making up the summary a low value for the co-efficient of discharge has been allowed, as the soil is mainly of a sandy nature.

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*These sewers are probably adequate for storm water for their present drainage areas under the present conditions, but will not be adequate if the area is further developed as to pavements, etc.

## Table Showing the Size, Slope, Drainage Areas and Capacities of the Paterson Sewers.

| | Street. | Size and shape of sewer | Present drainage area in acres | Ultimate Drainage area in acres | Controlling Slope of outlet per 1,000 ft. | Discharge cu. ft. per second | Discharge in inches of rainfall per hour On present aera | Discharge in inches of rainfall per hour On ultimate area | Average slope of ground per 1,000 | McMath's coef. of Discharge |
|---|---|---|---|---|---|---|---|---|---|---|
| South Side | Prospect | 54″ Egg Shape | 105.8 | 440.8 | 11.2 | 173.0 | 1.63 | 0.44 | 14.70 | 0.96 |
| | Mulberry | 18″ Circular | 3.0 | 3.0 | 17.8 | 14 2 | 4.73 | 4.73 | 37.5 | 0.7* |
| | West | 18″ Circular | 3.0 | 3.0 | 6.5 | 8.2 | 2.72 | 2.72 | 15.0 | 0.7* |
| | Bank | 24″ Circular | 3.5 | 3.5 | 8.6 | 20.5 | 5 81 | 5.81 | 14.0 | 1.1* |
| | Main | 18″ Circular | 16.5 | 16.5 | 2.7 | 5.1 | 0.31 | 0.31 | 22.6 | 0.3* |
| | Bridge | | 47.7 | 47.7 | | | | | 17.0 | |
| | Montgomery Twin Sewer | 54″ Circular | 348.8 | 348.8 | 1.02 | 109.2 | 0.31 | 0.31 | 10.3 | 0.26 |
| | Straight | 36″ Egg Shape | 107.5 | 107.5 | 0.6 | 14.0 | 0.13 | 0.13 | 16.2 | Less than 0.1 |
| | Franklin | 12″ Circular | 2.0 | 2.0 | 19.8 | 5.2 | 2.56 | 2 56 | 50.0 | 0.5* |
| | Keen | 15″ Circular | 23.6 | 23.6 | 19.1 | 9.2 | 0.39 | 0.39 | 25.9 | 0.2* |
| | Warren | 30″ Egg Shape | 44.6 | 162.9 | 13.4 | 45.6 | 1.02 | 0.28 | 27.4 | 0.46 |
| | Lowe | | 4.6 | 8.6 | | | | | | |
| | Wood | | 4.0 | 8.3 | | | | | | |
| | E. 5th, Private | 24″ Circular | 3.5 | 3.5 | 7.5 | 19.1 | 5.43 | 5.43 | 26.7 | 1.0* |
| | E. 11th St. | 36″ EggShape | 102.9 | 102.9 | 7.6 | 54.9 | 0.53 | 0.53 | 29.4 | 0.28 |
| | 4th Ave. | 30″ Egg Shape | 29.2 | 29.2 | 4 3 | 24 5 | 0.83 | 0.83 | 21.0 | 0.35 |
| | 2nd Ave | 30″ Egg Shape | 22.0 | 22.0 | 5.3 | 27.4 | 1.24 | 1.24 | 10.0 | 0.58 |
| | 3d Ave. | 30″ Egg Shape | 52.3 | 82.5 | 4.2 | 24 2 | 0.46 | 0.29 | 12.15 | 0.26 |
| | 33d St. | 60″ Egg Shape | 552.7 | 571.3 | 12.3 | 272.5 | 0.49 | 0.47 | 9.5 | 0.44 |
| | 20th Ave. | 42″ Egg Shape | 18.1 | 136.0 | 6.5 | 74.0 | 4.05 | 0.53 | 11.5 | 1.5* |
| | Market street on Vreeland Ave. | 84″ Circular | | | 3.4 | 335.0 | 0.403 | 0.22 | 5.7 | 0.47 |
| | Market St. | 94″ Circular | 820.0 | 1504.5 | 12.5 | 960.0 | 1.15 | 0.63 | 9.4 | 1.2 |
| North Side | 36″ Iron Pipe | | 56.0 | 56.0 | | | | | | |
| | N. West & Hamburg Ave. | 72″ Circular | 223.0 | 260.0 | 5.5 | 289.0 | 1.29 | 1.10 | 23.2 | 0.82 |
| | N. Main & Temple | 30″ Egg Shape | 13.0 | 13.0 | 1.8 | 15.2 | 1.16 | 1.16 | 9.7 | 0.60 |
| | Arch | 30″ Egg Shape | 30.0 | 30.0 | 3.0 | 20.1 | 0.67 | 0.67 | 12.5 | 0.35 |
| | Jefferson | 24″ Egg Shape | 34.0 | 34.0 | 6.4 | 17.0 | 0.49 | 0.49 | 27.4 | 0.20 |
| | N. Straight | 36″ Egg Shape | 54.0 | 68.0 | 5.3 | 45.3 | 0.83 | 0.67 | 32.1 | 0.38 |
| | Bergen | 18″ Circular | 5.6 | 5.6 | 3.5 | 5.9 | 1.05 | 1.05 | 10.2 | 0.5* |
| | Short | | 21.6 | 21.6 | | | | | | |

*Approximate.

## APPENDIX NO. IX

### REPORT OF WESTON E. FULLER UPON

# GAUGINGS OF PATERSON SEWERS.

I beg to present herewith my report upon the gaugings of the flow of sewers in Paterson.

Two sets of gaugings were made. The first set was made on April 17th, 18th and 19th. There was a little rain on April 15th, and there was, of course, a great deal of ground water at that time.

The second set of gaugings was made on June 11th and 12th. There was no rain of any amount for a week previous to this data. It is considered that this is very nearly the dry-weather flow. The gaugings were taken by means of floats and measurements of the section of the flow. Where possible this was taken at two manholes. The average velocity between manholes was taken, as well as the local velocity at each manhole. From these data the velocity used in the computations was selected.

In making the first set of gaugings it was difficult to get the velocity in many of the sewers as the water was backed up from the river. The sediment and irregular sections made the gaugings more difficult to get accurately. In the main, however, I think the last set of gaugings represents very well the approximate flow at that date. In some cases it was impossible to get any gaugings. In these cases the flow was estimated, account being taken of the character of the drainage area, etc.

Dye wastes were very noticeable in some of the sewers. These wastes evidently fluctuate largely and at frequent intervals during the day. The accompanying table gives the results of the computations on the flow. As all the gaugings were taken between the hours of 10.00 a. m. and 5.00 p. m., a deduction of 20 gallons per capita is made from the flow as measured.

## GAUGINGS OF PATERSON SEWERS.

| | April 17-19, 1906. | | June 11-12, 1906. | |
|---|---|---|---|---|
| South Side of River. | Time of day. | Discharge, million gals. per day. | Time of day. | Discharge, million gals. per day. |
| Prospect St., | | 0.85* (Est.) | 4.00 P. | 0.48 |
| Mulberry St., | | 0.06* " | 2.40 P. | 0.03 |
| West St., | | 0.11* | 2.30 P. | 0.05 |
| Bank St., | 0.05 | 0.05* " | 2.15 P. | 0.05 |
| Main St., | 12.15 P. | 0.16* | 4.30 P. | 0.23 |
| Bridge St., | | 0.70 (Est.) | 1.00 P. | 0.65 (Est.) |
| Montgomery St., | 1.00 P. | 3.00* | 1.30 P. | 5.00 |
| Straight St., | 1.30 P. | 0.69* | 12.55 P. | 0.98 |
| Franklin St., | 2.00 P. | 0.02 | 12.45 P. | 0.02 |
| Keen St., | | 0.20 (Est.) | 12.30 P. | 0.10 |
| Warren St., | 2.25 P. | 2.08* * | 12.15 P. | 0.43 |
| Wood St., | | 0.10 (Est.) | 12.00 M. | 0.63§ |
| Lowe St., | | 0.10 (Est.) | | 0.05 (Est.) |
| Eleventh St., | 2.50 P. | 0.09 | 10.45 A. | 0.34§§ |
| Fourth Ave., | 2.30 P. | 0.19 | 11.20 A. | 0.09 |
| S | | | | |
| Second Ave., | 2.00 P. | 0.05 | 11.40 A. | 0.03 |
| Third Ave., | 1.30 P. | 0.32 | 12.00 M. | 0.05 |
| Thirty-third St., | 12.30 P. | 2.01 | 12.30 P. | 0.52 |
| Twentieth Ave., | 11.45 A. | 0.14 | 3.00 P. | 0.11 |
| Market St., | 11.45 A. | 7.35 | 2.30 | 3.55 |
| North Side of River. | | | | |
| 36-inch iron pipe, | | 0.62 (Est.) | | 0.20 (Est.) |
| No. West St., | 5.00 P. | 2.75* | 2.55 P. | 0.97 |
| No. Main St., | 4.20 P. | 0.13 | 3.30 P. | 0.10 |
| Arch St., | | 0.20* (Est.) | 3.35 | 0.10 |
| Jefferson St., | | 0.30* (Est.) | 3.40 P. | 0.23 |
| No. Straight St., | 2.30 P. | 0.63* | 3.55 P. | 0.71 |
| Bergen St., | | 0.06* (Est.) | 4.10 P. | 0.02 |
| Short St., | | 0.20 (Est.) | | 0.08 (Est.) |
| Total, | | 23.16 | | 15.80 |
| Deduct for excess of day flow over average flow, | | 2.23 | | 2.23 |
| Daily flow, | | 20.93 | | 13.57 |

* Sewers flooded with back-water from the river, so that these gaugings were only a rough approximation.

** The large quantity in this sewer on April 17th was due to dye-waste. On June 11th no dye-waste was observed, probably owing to the fact that it was gauged during the noon hour.

§ Nearly all dye-waste.

§§ About 60 per cent dye-waste. Gauging taken above mill shows only 0.10 million gallons per day.

Note: Dye-waste was noted in the following sewers:

Keen street,
Warren street,
Wood street,
Eleventh street,
No. West street,
No. Straight street.

### APPENDIX NO. X

## VOLUME OF SEWAGE TO BE PROVIDED FOR.

The total mileage of sewers in Paterson, according to City Engineer Harder, is about 80 miles. There are no complete records of most of these sewers, as all records were lost in the fire some years ago. There is a printed report giving the streets in which sewers have been built and the sizes of each sewer, and the present sewer map is based largely upon information contained in this report. Information as to which way the sewers drain was not in the report, and there was often some doubt as to this.

**Memoranda of Talk with Mr. Ferguson.**

Mr. William Ferguson, former City Engineer, thinks that in nearly all cases the designs for sewers were sufficient to take care of the quantities to be provided for. He states that there is no quicksand and good bottom is always encountered. In his judgment there would be no rock excavation in building the intercepting sewer, but in other parts of the city a great deal of rock has been excavated for sewers. The trench would of course be wet below river level, but the material would always be firm and satisfactory to build upon.

In some cases considerable difficulty has been experienced in locating sewers, as all macadam roads are built by the county, and in building them no attention is paid to manholes. Grades are frequently raised and the thickness of the streets increased, and the manholes are sometimes buried beneath a considerable thickness of road material.

Generally the inverts of the sewers are ten feet below the finished surface of the street, except in the case of large sewers, which are usually a little deeper. In a few cases the sewers are too small and heavy rains produce flooding of cellars, etc., but this is not a common condition.

Sewers up to four feet in diameter are egg-shaped; all larger ones are circular.

**Population Tributary to Sewers.**

The present population of Paterson is 111,529. Not all of this population is connected with the sewers. There are in the city about 2,000 vaults with no water or sewer connections, and 1,500 vaults with connections. I assume that the vaults where there are water closets are used to only a slight extent, say 20 per cent. of the full amount; and I take the number of vaults for the purpose of calculation as that of the vaults having no connection, or 2,000, and 20 per cent. of vaults with water closets, or 300, making a total of 2,300 vaults, and assuming six people to a vault makes 13,800 of the population not connected with the sewers. This leaves 97,729 tributary to the sewers.

## VOLUME OF SEWAGE.

**First, Volume from Public Water Supply.** For the purpose of this estimate I assume that the average daily consumption of water for the purpose of sewage disposal is 75 gallons per capita daily, or for the present population, about 8,400,000 gallons, and it is assumed that this amount will increase in the same ratio as the population.

**Second, Volume of Manufacturing Wastes.** The amount of water used for manufacturing purposes in Paterson is variously estimated from 15 to 20 million gallons per day. Much of this is well-water. A large part comes from tributaries of the Passaic river and is often filtered before use, while a considerable part comes from the Passaic river itself above the most important points of pollution, and that is also filtered before use.

Most of the volume of water is used in the dyeing of silk. The process of silk dyeing results in the production of a small volume of soapy dye liquors which are very concentrated; also, in a greater but still small volume, of wash-waters of a fair degree of concentration and which presumably make some trouble in the river; and also of an extremely large volume of wash-waters and waters containing mineral substances, such as chloride of tin or chloride of calcium after the tin has been extracted, phosphate of soda and silicate of soda. Liquors of this kind constitute the great bulk of the volume of manufacturing wastes. They contain nothing injurious and there is no reason for keeping them from the river.

It therefore will be necessary to give the dye works connections with the sewers and to require them to put their objectionable liquors in the sewer, but to continue putting the slightly polluted wastes into the river as at present.

The volume of liquors from the dye-houses of such character that they need to be kept from the river, on available evidence, does not exceed one million gallons per day. On account of the impossibility of exact separation I double this estimate, and allow two million gallons per day for waste liquors, or eighteen gallons per capita daily, and I assume that this will increase at the same rate as the population.

**Third, Volume of Ground and Storm Water.**

The area now actually tributary to the Paterson sewers, according to our studies and computations, is 2,752 acres, or just about half of the total area of the city. The total amount of run-off from this area can be estimated with approximate accuracy, at 1.11 million gallons per day and per square mile for 4.3 square miles, or 4.8 million gallons per day. This includes both surface run-off and the underground run-off. A close classification of the ways in which this run-off will go is impossible. For the purpose of this estimate I shall divide it into three parts, namely, one-third, or 1.6 million gallons per day going to the wells of manufacturing concerns that draw ground water. The amount of ground-water actually drawn by the mills is larger, probably several times this amount, but they also draw from the unsewered parts of the city, and no doubt also from areas outside the city. These wells are largely located in the sewered sections, however, and it is fair to assume that they draw water from the sewered area to the extent mentioned.

One-third, or 1.6 million gallons per day as surface run-off from storms, reaching the sewers in a comparatively small portion of the time and under present conditions in such quantities that it will be necessary to allow it to overflow to the river. This water therefore does not contribute to the volume of sewage that must be purified. So far as the separate system is installed this water will go to the river direct and will be without influence upon the sewerage system.

One third, or 1.6 million gallons per day entering the sewers as ground water in a fairly steady flow, varying somewhat in different parts of the year, but in such quantities that all of it will add to the volume of sewage which must be purified. This amounts to 15 gallons per capita daily of the present population, and it is assumed that this ratio will be maintained, for the sewers will be extended to other districts not now tributary to them as the population increases.

The total quantity of sewage requiring treatment may therefore be estimated as follows :

| | Million gallons per day. | Gallons per capita daily. |
|---|---|---|
| From the water supply | 8.4 | 75 |
| From the mills | 2.0 | 18 |
| From ground water | 1.6 | 14 |
| Total | 12.0 | 107 |

Gaugings have been made of the sewers as far as they are accessible, estimates being included for a few sewers where the manholes were inaccessible so that direct gaugings could not be made. These gaugings were made in the daytime, and I have assumed that the average discharge of sewage was 20 gallons per capita daily less than the rate observed at the time of gauging.

On this basis the total quantity of sewage discharging into the river on April 17th was twenty-one million gallons per day. This is substantially the period of the year when the ground water flow is greatest, and therefore represents a figure far above the average.

On June 11th the corresponding quantity was 13,500,000 gallons per day, or about 120 gallons per capita.

For the purpose of estimate the following values are used:

| | |
|---|---|
| Dry-weather flow | 100 gallons per capita daily, |
| Average flow to be treated, or carried away in intercepting sewers | 125 gallons per capita daily. |
| Maximum quantity to be treated or carried away in intercepting sewers | 250 gallons per capita daily. |

and it is assumed that all flow of the sewers in excess of this last figure will be allowed to discharge through storm overflows to the river. This overflow will be greatly reduced as the separate system is installed.

**Size of Works.** The quantities of sludge and the cost of operation are to be based on the average quantities of sewage estimated as above, and with the assumption that the quantities will increase in the future at the same ratio as the population. The capacities of the different parts of the works must be sufficient to handle the maximum quantities of sewage.

Without attempting close refinements I shall assume that the capacity of the sewers, force mains, etc., should be double the annual average quantity of sewage, which should fully cover all possible fluctuations in consumption.

The pumping capacity should be at about the same figure, but may be varied slightly in this way: The pumping capacity of all the units should not be less than 2¼ times the average annual rate, and the capacity of the pumps with one unit out of service should not be less than 1¾ times the annual amount of sewage.

Filters, septic tanks, etc., are to be figured upon both the annual average and maximum consumptions, the two figures being both stated; but in connection with the filters it should be remembered that the normal operation is at a high rate for a fraction of the time, and as this corresponds somewhat with the fluctuations in the sewage, it will be unnecessary to provide filters to take care of the maximum rates and allow for rest periods. The same will apply to a less extent to settling basins, etc., where the rates of passage will necessarily fluctuate with the quantities passing.

## APPENDIX XI.

### OPINION OF CITY COUNSEL EDMUND G. STALTER, AS TO THE

# USE OF BERGEN COUNTY LAND BY THE CITY OF PATERSON.

February 14, 1906.

To William S. Ackerman, Esq.,
Secretary of the Joint Committee on Sewage Disposal,
Paterson, N. J.

Dear Sir:

Seven questions have been submitted to me for legal investigation by your committee relative to the powers of the City of Paterson in connection with the construction of sewage purification works.

I have investigated the different statutory enactments of the State of New Jersey relative to these matters, and I will answer your several questions in the order they were submitted to me.

I find that there are two acts which seem particularly applicable to our condition; one is entitled, "An Act to allow towns, villages, or other municipal corporations to acquire and use lands or real estate in an adjoining township or municipal corporation for use for the construction of a sewage receptacle or sewage disposal works." Approved April 9, 1892, found on p. 452 of the General Public Laws of 1892.

This is a short act, and provides in section one that it shall be lawful for the governing body of any municipality to secure by purchase or condemnation or otherwise in any municipal corporation, the necessary land and real estate for the erection or construction of any sewage receptacle or works or place for treating or disposing of the sewage etc., of said municipality.

Section 2. Provides that before preparing said land or real estate for the disposal of the sewage or house waste of said city where said land or real estate is in a municipality other than the one constructing the works, it shall be necessary to secure the consent by a resolution of the governing body of said municipality within whose boundaries such lands are located; such resolution must receive the votes of the majority of members of such governing body.

This act renders possible the answering in the affirmative of the first six questions submitted by your Committee. I would say, however, that the act is not complete, because it provides nothing beyond the mere elementary steps, there being no provisions made for the cost or the actual operation of the necessary work.

The second act to which I referred is entitled, "An Act to provide for drainage and sewage in cities of this State." Approved April 7, 1890.

This act was amended by an act passed in 1894. Under the provisions of these two acts the city has the power to construct a system of sewerage and drainage whenever the owners of at least one-half in value of the real estate in said city, as shown by the assessors' books, shall petition the Board of Aldermen so to do. This act takes up the entire matter, and seems to provide for the very conditions which now face your Committee.

The first section, however, which requires a petition from the owners of at least one-half in value of the real estate in said city, seems to be almost prohibitory. The remaining portion of the act, however, treats the matter in a very systematic way.

Section 7. Further provides that in case the governing body shall deem it expedient to collect the sewage of the city or of any part thereof from any sewer or sewers constructed under the said act or any act of the legislature of the state, and to deodorize, utilize, condemn or dispose of the same by sale or otherwise, wholly or in part, it shall be lawful for said Board of Aldermen to purchase lands in the corporate name of the city, and to erect all necessary buildings, works and machinery thereon, and to take and appropriate for such purpose any lands and real estate upon making compensation to the owner or owners as hereinafter provided.

Section 8. Provides that when an ordinance has been passed directing the construction of a sewage system under this act, that all further acts and proceedings necessary to be taken may be by resolution and not by ordinance.

Section 9. Provides that the ordinance for making this sewage improvement shall not be acted upon until public notice has been given as in said section provided.

Section 10. Provides that the Board of Aldermen, after the passage of such an ordinance shall appoint by ballot from their own number a committee to be called "The Committee on Sewers," which shall have charge of the work under the supervision of the said Board of Aldermen. The section goes on to provide for the details of such work.

Section 11. Provides that whenever the Board of Aldermen shall have determined by ordinance to construct any sewer or sewers, drain or drains, or any sewage receptacle or pumping station, or other structure or work for treating or disposing of water or sewage, and shall deem it necessary to take and appropriate for any such purpose, any lands and real estate either within such city or beyond its limits, they are hereby authorized to treat with the owner or owners thereof for the same, and may purchase said lands and real estate.

Sections 12, 13, 14 and 15 provide for a method of condemnation where no agreement can be made for the purchase of said lands.

The remaining sections of said act take up the matters of assessment of damages, the issuance of bonds, and other matters of detail to carry out the provisions of the act.

Your Committee will see by reading over the acts above mentioned that one provides for the elementary steps in the procedure, while the other provides a complete system with the exception of the prohibitory clause in section one.

As to the last question submitted, the legislature can grant any further powers that are necessary for the completion of the work, provided such powers are not prohibited by the constitution.

Very truly yours,
(Signed) EDMUND G. STALTER,
City Counsel.

APPENDIX NO. XII.

## PRICES OF COLUMBUS SEWAGE DISPOSAL WORKS.

| | |
|---|---|
| Excavation, 126,450 cubic yards, @ 42c. | $ 52,900 |
| Embankment, paving, roads, sodding, seeding, etc. | 8,885 |
| Masonry, brick and concrete, 24,366 cu. yds. @ $5.28. | 128,594 |
| Steel rods in masonry, 85 tons, @ $60 | 5,100 |
| 6 inch lateral collectors, 530,000 feet @ $0.065 | 34,450 |
| Other vitrified pipe | 4,156 |
| 2,100 risers and nozzles, complete | 3,985 |
| Sprinklers | 3,010 |
| Filtering material, 82,000 cu. yds, @ $1.57 | 128,740 |
| Cast iron pipe and specials | 9,132 |
| Gates and sluice gates, and appurtenances | 33,063 |
| Venturi meters, controllers, centrifugal pump and gas engine | 11,578 |
| House fittings and all minor items | 14,493 |
| Total | $438,086 |

I understand that the engineer's estimate on this work was about $495,000, or about 13 per cent. more than the above prices; and in using them as a basis for estimate it would certainly be fair to make a corresponding addition, and also a reasonable allowance for extras.

Assuming the fair cost of the completed work to be $500,000 I should divide it approximately as follows:

| | |
|---|---|
| Septic tanks and settling basins, holding 10 million gallons, at $8,000 per million gallons | $ 80,000 |
| 10 acres of sprinkling filters, complete, at $42,000 | 420,000 |
| | $500,000 |

The filters at Columbus are to be only five feet deep. Those estimated for Paterson are to be twice as deep, and will therefore cost more.

It is understood that the contracts were let at these prices. The works are now under construction, and it is impossible to tell just what the completed cost will be.

APPENDIX NO. XIII

# FLOW OF THE PASSAIC RIVER AND DIVERSION OF WATER.

The area of the Passaic river at Dundee dam is given in the Geological Survey of New Jersey for 1894, page 103, as 822.5 square miles. The minimum flow of the Passaic river at Passaic is given in the Water Power Census for 1880 as 211 cubic feet per second, or 0.23 cubic foot per second per square mile. The report of the Passaic Valley Sewerage Commission, 1897, gives the minimum flow of the river as 120 cubic feet per second, page 33. Vermeule gives the flow as about 0.20 cubic foot per second per square mile, and I shall use this figure in the following computations.

On the basis of the flow at Passaic the minimum net flow of the river at Dundee Dam is 165 cubic feet per second, or 107 million gallons daily, sufficient to receive the sewage of a population of about 55,000 at 3 cubic feet per second, or 41,000 at 4 cubic feet per second, per thousand population.

Water has been diverted by Newark from an area of 62½ square miles, as given in table, page 19, of the annual report of the Board of Street and Water Commissioners of Newark for 1903. The water from an area of 121 square miles has been diverted by Jersey City, as given in Mr. Whipple's report for 1904. This makes a total diversion of 183.5 square miles. Subtracting this amount from the total leaves the net area to maintain the minimum flow at Dundee Dam at the present time as 639 square miles. The flow from this area on the basis above stated would be 128 cubic feet per second, or 83 million gallons per day.

There has been a further diversion of water by the East Jersey Water Company at Little Falls. The capacity of the present filter plant is 32 million gallons per day. There is a pumping capacity to pump raw water somewhat greater than this, but I assume that this will not be used. Deducting 32 million gallons daily from the flow as above leaves the present minimum flow of the Passaic river 51 million gallons, equal to 79 cubic feet per second, which must be anticipated at Dundee Dam in the next few years.

The quantity of water actually filtered at Little Falls in the year 1905 was about 23 million gallons daily. Using this figure instead of the full capacity of the plant, the present minimum flow of the stream which must be reasonably anticipated is 60 million gallons, or 93 cubic feet per second. This amount is sufficient to give four cubic feet per second per thousand of population for a population of 23,000.

**Water Supply Conditions.** The population in northern New Jersey within a reasonable distance of New York, by the census of 1905, is roughly 1,065,000. The most of this population must ultimately be supplied with water from the Passaic river above Dundee Dam. At the present time about 185,000 of this population are supplied with water from the Hackensack river, the towns included being Hackensack, Hoboken, West Hoboken, Englewood, and perhaps twenty small towns and villages.

The watershed of the Hackensack river is not capable of large development, is being built upon, and it would seem that the population now supplied from it was destined sooner or later to be supplied from the Passaic river watershed. Some of the Oranges and other towns in the area mentioned are supplied with ground water supply.

The population now supplied with Passaic water is roughly as follows:

| | Population, 1905. |
|---|---|
| Paterson | 111,529 |
| Passaic | 37,837 |
| Montclair | 16,370 |
| Newark | 283,289 |
| Jersey City | 232,699 |
| Kearney | 13,601 |
| Harrison | 12,823 |
| Bayonne | 42,262 |
| Belleville | 7,632 |
| Irvington | 7,180 |
| Nutley | 4,556 |
| Total | 769,778 |

**Quantity of Water.** The quantity of water which could be obtained in a dry year from the Newark and Jersey City watersheds, upon the Sudbury basis, is as follows:

The areas and storage capacities for Jersey City are taken from memoranda by Mr. Whipple. The figures from Newark are taken from the report of the Board of Public Works for that city.

| | Total area. | Square miles water surface. | Square miles land area. | Per cent. water surface. | Storage in Million Gals. | | Safe yield per square mile of land area. | Total safe yield in a dry year on Sudbury basis. |
|---|---|---|---|---|---|---|---|---|
| | | | | | Total. | Per sq. mi. of land area. | | |
| Boonton.. | 121 | 1.21 | 119.79 | 1 | 7,186 | 60 | 430,500 | 51.5 |
| Newark. | 62.5 | 2.62 | 59.88 | 4.2 | 9,092 | 152 | 690,000 | 41.3 |
| Little Falls.... | | | | | | | | 32.0 |
| Total development (=162 gallons per capita of population now supplied)........ | | | | | | | | 125 |

In making this computation the storage capacity of the Ridgewood reservoir is included in the storage available on the water-shed, but it is assumed that the rainfall and evaporation on the reservoir will balance, and neither its water-shed area nor the area of its surface are included in the totals above given.

The Newark water works were planned by Mr. Clemens Herschel to have a dry-weather capacity of 50 million gallons per day, without the Ridgewood reservoir. Mr. Sherrerd is clearly of the opinion that they are not good for so much as that. With the Ridgewood reservoir he is of the opinion that they were good for about 47 million gallons per day, or 14 per cent. more than rated above. This is based on actual experience with them since they were built, and of course does not cover the years for which the flows on the Sudbury and Croton were lowest, and which control in the computation by the method used.

**Flood Prevention.** Reservoirs have been proposed to prevent the recurrence of extreme floods in the Passaic valley by holding back some of the running-off at these times. A reservoir for this purpose would ordinarily be kept empty and would be filled during periods of exceptional run-off. The water so accumulated would be allowed to run out afterward at a harmless rate.

The report of the Passaic Flood Commission contains data for and estimates of cost of construction of a number of such reservoirs. In figuring as to flood condition, the total area of the water-shed should be taken into account, for a flood may obviously occur when the reservoirs for water supply purposes are full, and when the run-off from them would be substantially as great as if the reservoirs did not exist.

The amount which a given flood could be reduced clearly would not exceed the percentage which the flood area back of a particular reservoir is of the total water-shed area above Dundee Dam. The available capacity of such a reservoir need not be greater than sufficient to hold the run-off from the water-shed tributary to it of a flood equal to the greatest flood on record ; and in making this computation the run-off need be included only for so long a period as the total flood exceeded in volume the computed maximum volume of the flood as it would be with the reservoir built and with that part excluded. That is to say, it is only necessary to count on the use of the reservoir for such period as the total flow from the whole water-shed could exceed the flow from the parts of the water-shed exclusive of the area above the dam.

From a study of the report of the Passaic flood of 1903, by Marshall O. Leighton, Water Supply & Irrigation Paper No. 92, it appears that the total run-off for nine days and nine hours was 14,772 million cubic feet, amounting to 7.73 inches of run-off on the tributary watershed, and this may be taken roughly as the limit of storage capacity which will be used for the purpose of preventing floods. Of this amount, in four days the run-off was 4.5 inches, and it would seem as if a storage of 4.5 inches was sufficient. The Flood Commission, however, used eight inches, which seems very liberal.

The report of the Passaic Flood Commission for 1904 suggests that while such reservoirs were being built they might be constructed larger than was necessary for the purpose of flood prevention, and in that case that part of the full capacity useful for preventing floods might be dedicated to that purpose, while the balance of that capacity might be used for increasing the lower flow of the Passaic in the lower reaches. In this way it would be possible to maintain a greater minimum flow than now exists, and thereby the sewage from the population which could be harmlessly discharged, would be greatly increased.

For the purpose of computing the minimum flow obtainable in this way, the watershed above Dundee dam, excluding the sections developed for water-supply, may be taken. The storage capacity may be taken as equal to the capacity of the dam, less that part of it corresponding to 7.73 inches of run-off on the watershed tributary to it, which is taken as its useful capacity for preventing flood.

The minimum flow may then be computed on the Sudbury basis, but taking the revised line which shows the amount which may be counted on for four years out of five. That is, it may be assumed that a condition which occurs only on each fifth year, and that usually for a short time, will not control, and that the conditions of four years out of five will practicably be the limit of the capacity for sewage disposal.

From the minimum run-off so computed must be deducted the amount of water to be developed at Little Falls, taken as the capacity of the plant, or 32 million gallons per day. The construction of the reservoirs proposed by the flood commission and at different elevations computed in this way are as follows :

| Watershed Area. | Proposed Reservoir. | Elev. above Sea Level | Drainage Area Tributary to this Reservoir Sq. Miles. | Total Capacity of Reservoir Million Gallons. | Amount of Total Capacity Dedicated to the Prevention of Floods. | Net Capacity Available for Increasing minimum Flow, Million Gallons. | Storage per sq. mi. on this basis Million Gallons. 639 sq. mi. | Approximate Net Safe Yield Million Gallons. | Deduct Amount taken by East Jersey Water Co. Million Gallons. | Net Minimum Flow Available. Million Gallons. | Net Minimum Flow Available Cubic Ft. per sec. | Population from which Sewage would be Adequately Diluted from this Flow cu. ft. per sec. per 1,000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Falls......... | Great Piece........ | 178.5 | 773 | 66,945 | 104,000 | 0 | 0 | 82 | 32 | 50 | 77.5 | 19,000 |
| Ramapo.............. | Ramapo.............. | 280 | 140 | 13,235 | 18,750 | 0 | 0 | 82 | 32 | 50 | 77.5 | 19.000 |
| Rockaway........... | Powerville.......... | 520 | 114 | 11,705 | 15.300 | 0 | 0 | 82 | 32 | 50 | 77.5 | 19,000 |
| Wanaque............ | Midvale............. | 275 | 83 | 11,150 | 11,100 | 50 | 00.8 | 84 | 32 | 52 | 80 | 20,000 |
| New Foundland.. | New Foundland.. | 780 | 52 | 7,225 | 6.900 | 325 | 0.51 | 87 | 32 | 55 | 85 | 21,000 |
| Millington.......... | Millington.......... | 245 | 56 | 30,368 | 7.500 | 22,868 | 36.9 | 130 | 32 | 98 | 151 | 38,000 |
| Pompton Plains.. | Mountain View... | 220 | 380 | 112,200 | 50,900 | 61,300 | 98.6 | 180 | 32 | 148 | 228 | 57,000 |

It should be noted that an increase in the minimum flow would be desirable from every standpoint in the valley, even though it were not sufficient to adequately dilute the sewage from the present poulation. The amount of minimum flow would have an important bearing upon the amount of storm overflow which could be allowed to go into the river, and upon the degree of purification necessary to be effected by purification works which might be established. It would therefore have an important bearing upon the cost of works necessary to put the river in reasonably good condition, even though it was not sufficient to dilute the whole sewage.

## APPENDIX NO. XIV.

# POPULATIONS OF 1905 OF PLACES SUPPLIED WITH PASSAIC WATER.

| | Population 1905 |
|---|---|
| Bayonne | 42,262 |
| Belleville | 7,632 |
| Harrison | 12,823 |
| Irvington | 7,180 |
| Jersey City | 232,699 |
| Kearney | 13,601 |
| Montclair | 16,370 |
| Newark | 283,289 |
| Nutley | 4,556 |
| Passaic | 37,837 |
| Paterson | 111,529 |
| Total | 769,778 |

## POPULATIONS OF 1905 OF PLACES SUPPLIED WITH HACKENSACK WATER.

| | |
|---|---|
| Bergen Fields | 1,095 |
| Carlstadt | 3,100 |
| Cliffside | 2,128 |
| East Rutherford | 3,165 |
| Englewood | 7,922 |
| Englewood Cliffs | 266 |
| Guttenburg | 4,563 |
| Hackensack | 11,098 |
| Hasbrouck Heights | 1,560 |
| Hoboken | 65,468 |
| Leonia | 1,041 |
| Little Ferry | 1,776 |
| Lodi | 2,793 |
| Maywood | 687 |
| Midland | 1,617 |
| North Bergen | 11,134 |
| Ridgefield Park | 745 |
| Riverside | 670 |
| Rutherford | 5,218 |
| Tenafly | 2,142 |
| Union | 17,005 |
| Wallington | 2,475 |
| Weehawken | 8,027 |
| West Hoboken | 29,082 |
| Total | 184,777 |

APPENDIX NO. XV.

# STATEMENT IN REGARD TO DRAINAGE AREAS ABOVE AND ABOUT PATERSON.

The sewers at the present time, from computations made in this office, drain 2,752 acres on the combined system. When the present sewers are extended to their ultimate limits this area will be increased to 4,116 acres. Other sewers in districts not yet developed will be required to drain the remainder of the city. When this is done the total drainage area will be 5,160 acres.

In addition to the area of the city proper there are a number of districts outside, resting in such a way with reference to the city that their sewage will necessarily most conveniently be handled in connection with the Paterson City sewers, and a consideration of them is thus necessary. These areas are as follows :

**1. Oldham Brook.** The total drainage area of Oldham Brook is 8.9 spuare miles. Of this, 7.9 square miles are out of the city limits. Oldham Brook flows through the city limits for a mile or more. There are no sewers upon its watershed at the present, time, either in or outside of the city.

There is a considerable population upon this watershed in the city of Paterson, and just outside in the village of Haledon. There are a number of manufacturing plants upon the stream. The watershed is hilly and very attractive for residential purposes. There are many large houses upon it at the present time. There are no railroads and the trolley extends to Haledon only.

The natural advantages of this country are such that there is sure to be a very considerable population, and population of a class that will certainly require sewers. The only natural outlet for sewers from the entire valley is through the city of Paterson. The population is now greatest at the lower end, and this condition will continue. There is no chance for separate sewage purification works, and the only possible disposition of sewage, which must certainly be taken care of before many years, will be through the Paterson sewers.

**2. Goffle Brook.** The total drainage area of Goffle brook is 9.5 square miles, and is entirely outside of the city limits. It enters the Passaic river from the north, just below the city limits. The Arnold Print works are located near its mouth and are supplied with water from it. Weidmann's dyehouse is almost across the river from its mouth, and uses, except at floods, the entire flow of the stream except that taken by the Arnold Print works.

Upon the watershed are quite a number of villages, among them North Paterson, Midland Park and Wortendyke. Much of the watershed is very attractive for residential purposes. The Susquehanna railroad runs through it and affords transportation.

I do not know how far sewers have now been built, but the population is certainly of a kind requiring sewerage facilities. It might be possible to build purification works for the sewage from Wortendyke and Midland Park, but there is clearly no opportunity to build such works for the increasing population on the lower part of the watershed. When this sewage is kept out of the Passaic river, the only satisfactory way of handling it will be through the Paterson sewers.

**3. Peckman Brook.** The drainage area of Peckman Brook is 9.9 square miles and is all outside of the city limits. Peckman Brook enters the Passaic river from the south, below Little Falls. The region is on the west side of Watchung mountain, is picturesque and suitable for residential purposes, and has transportation facilities by the Caldwell branch of the Erie Railroad, and also by trolley running over to Verona to Montclair.

The population now upon this water-shed probably does not immediately call for the consideration of sewers, but it is certain that sewers will be demanded in time, and when this happens, it will be very difficult to secure an outlet except through the Paterson sewers.

**4. Territory Directly Tributary.** To the Passaic River above the city limits and below Little Falls, but including Little Falls and Singac village.

The total drainage area is 4.7 square miles. It is developing and will require sewers, and there is no outlet for such sewers except through the Paterson system.

**5. Other Territory in Saddle River Township, etc.** This includes a belt of land extending from Goffle Brook to the Susquehanna Railroad, and east and west of the Bergen County cut-off, extending north to Glen Brook, including the village of Hawthorne, with a total area of about seven square miles.

This territory would naturally be drained by a series of short sewers, each leading directly to the Passaic river. The proximity of this territory to Paterson and the transit facilities afforded by the railways and trolley lines passing through it are such that it is certain sewers will be required.

This sewage could be collected in an interceptor on the east side of the Passaic river, or the sewage from each sewer as built could be taken under the river in siphons to the interceptor on the Paterson side. The sewerage of this territory could be handled without reference to Paterson, as apparently that of the first four areas mentioned could not be ; but very likely its most convenient and economical disposition would be through the Paterson sewers.

**In General.** So far as the sewers from this outside territory are allowed connection with the Paterson sewers it should be rigidly insisted that all sewers so connected shall be upon the separate system, and protected as far as possible from the entrance of ground water.

To provide for the adequate and economical removal of surface water it would be wise to reserve a strip of land along the bed of each stream, sufficient to carry the flood flows, and to reserve this strip forever from buildings. The land so reserved is least desirable for building purposes, and its reservation will not detract from the value of the territory as a whole. Reserving such adequate waterways for surface water will prevent very large expenditures for drains later on, which expenditures will very likely be so large as to seriously tax the resources of the towns when they would be required. Such strips further can be used for park purposes, and add greatly so the attractiveness of the region.

**Saddle River Territory.** There are a number of thriving towns on Saddle river. Lodi, Rochelle Park, and others will no doubt require sewers, and should be connected with the trunk sewer in Passaic when this occurs.

Above there is quite a strip of rather flat territory, without very good transportation facilities and without population requiring sewers at this time. Ridgewood has just been building sewers, and has constructed a sewage purification plant. This may be taken as an indication that the city intends to take care of its sewage locally, and this can be done probably for many years to come. It therefore seems unnecessary to treat Saddle river, above the vicinity of

Rochelle Park at the Susquehanna crossing, as a part of the Passaic district. The area of this district outside of the proposed Passaic valley district is 6.4 square miles, and would be naturally tributary to the Passaic sewers.

SUMMARY OF DRAINAGE AREAS ABOUT PATERSON.

| | Area, sq. miles. | Population, 1905. | Population per square mile. |
|---|---|---|---|
| Peckman Brook .......... | 10 | 4,000 | 400 |
| Territory above city and below Little Falls.......... | 5 | 3,000 | 600 |
| Oldham Brook............. | 9 | 4,500 | 500 |
| Total above city............ | 24 | 11,500 | 480 |
| Paterson.................. | 8 | 111,000 | 13,900 |
| Goffle Brook............... | 9.5 | 5,700 | 600 |
| Saddle River Township..... | 7.0 | 4,900 | 700 |
| Total to Dundee Dam....... | 48.5 | 133,100 | 2,700 |

## APPENDIX NO. XVI.

# AREAS, POPULATIONS AND VALUATIONS OF PLACES IN THE PASSAIC VALLEY SEWERAGE DISTRICT.

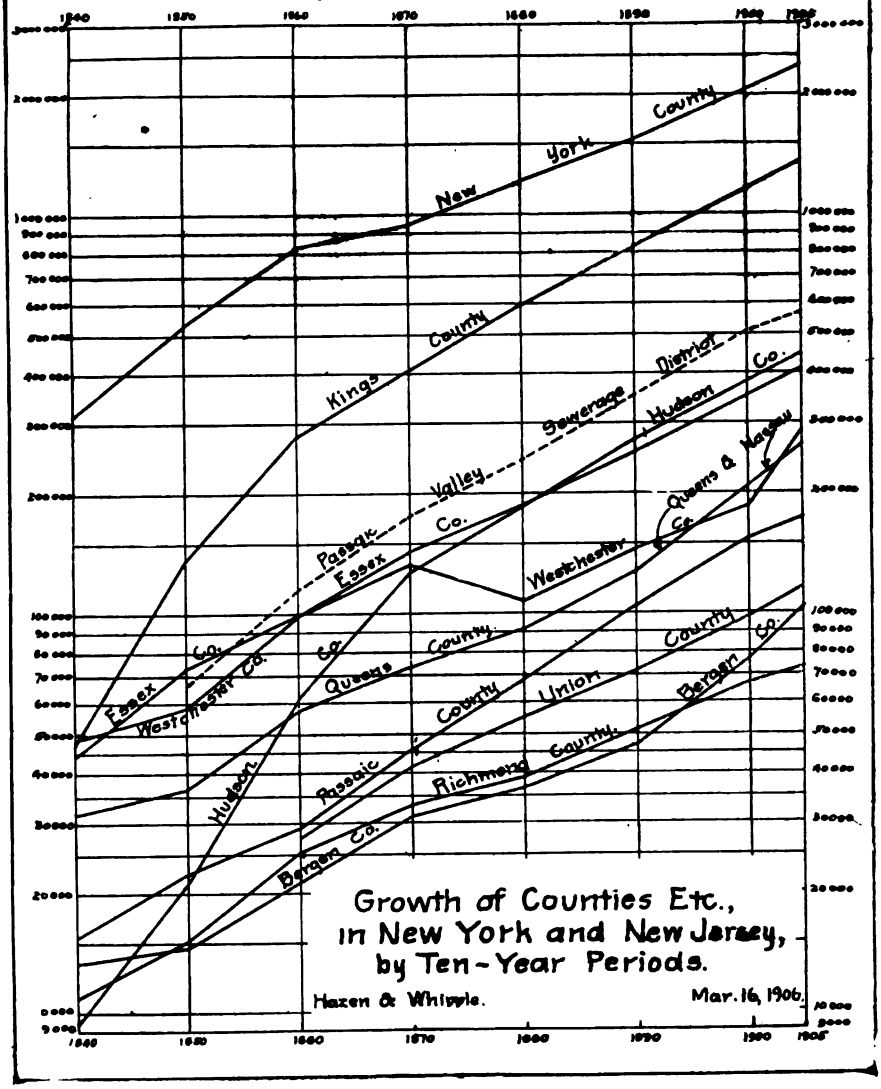
Drainage areas measured from New Jersey Geological Survey maps.

The population given is the percentage of the total population in the different towns in the district, as reckoned from the percentage of valuations taken by the Passaic Valley Sewerage Commission in the report of 1903.

The valuations are the net valuations taxable, as given in the report of the Board of Equalization of Taxes for 1905, and include both real estate and personal property.

| Place. | Area, square miles. | Population in area, census of 1905. | Net Valuation, 1905. |
|---|---|---|---|
| Passaic County. | | | |
| Paterson | 8.1 | 111,529 | $ 58,265,340 |
| Passaic | 3.2 | 37,837 | 12,391,344 |
| Acquackanonk | 11.4 | 7,187 | 2,435,200 |
| Essex County. | | | |
| Nutley | 3.5 | 4,556 | 1,919,400 |
| Belleville. | 3.6 | 7,632 | 2,698,449 |
| Newark | 19.2 | 282,439 | 189,598,217 |
| Montclair | 6.2 | 16,370 | 12,170,079 |
| Glen Ridge | 1.3 | 2,362 | 2,040,000 |
| Bloomfield | 5.1 | 11,668 | 6,337,400 |
| Orange | 2.1 | 26,101 | 11,530,479 |
| East Orange | 3.9 | 25,175 | 20,504,600 |
| Bergen County. | | | |
| Garfield | 2.2 | 5,092 | 1,313,192 |
| Lodi | | 297 | 62,892 |
| Hasbrouck Heights | | 165 | 92,747 |
| Wallington | 1.1 | 2,475 | 471,917 |
| Woodbridge | | 72 | 45,275 |
| Carlstadt | | 310 | 83,306 |
| East Rutherford | | 1,420 | 586,594 |
| Rutherford | 1.5 | 2,290 | 1,742,869 |
| Union | 1.46 | 1,180 | 361,925 |
| North Arlington | 0.8 | 216 | 143,011 |
| Hudson County. | | | |
| Kearney | 5.8 | 12,240 | 6,506,265 |
| East Newark | | 2,828 | 2,029,300 |
| Harrison | 1.33 | 12,823 | 5,588,787 |
| Total | 81.79 | 574,264 | $338,918,588 |

## Appendix XVII



Growth of Counties Etc., in New York and New Jersey, by Ten-Year Periods.

Hazen & Whipple.

Mar. 16, 1906.

### APPENDIX NO. XVIII.

# ON THE DISCHARGE OF SEWAGE INTO NEW YORK HARBOR.

BY ALLEN HAZEN.

BEING A DISCUSSION BY ALLEN HAZEN OF A PAPER PRESENTED BY DR. GEORGE A. SOPER TO THE SANITARY SECTION OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, FEBRUARY 7, 1906.

One of our New York dailies, speaking of Dr. Soper's admirable work in connection with the ventilation of the subway, referred to him as the best all-round germ detective in New York. I think he has fully justified that reputation tonight. Since he has investigated the oyster question I have had to forego the pleasure of eating them raw, almost entirely, and I am fond of oysters. It is only once in a great while, when he has been good enough to send up a bushel from his own private plantings, that I have been able to indulge that taste.

Mr. Weston has been talking to me about garbage disposal, and it was suggested that if we were more careful in our marketing, and if we had French cooks to save the scraps and to serve them to us in attractive form the day after, the quantity of garbage to be taken care of would be greatly reduced.

I do not know but we could go a little further. Supposing we were to regulate our food according to the dietaries of Mrs. Richards and limit ourselves to the number of calories that we really need, wouldn't the sewage disposal problem be largely solved? For I think that the troublesome matters are due largely to what we eat in excess of our actual needs. And that raises the question, what are the eating habits of the next generation going to be? Is it fair to make per capita computations based on the data of the present time and apply them to the twenty-first century, without taking into account the dietaries of the people at that time, which we cannot hope to know?

Some weeks ago I took up these figures which Dr. Soper has used tonight, as they are given in the printed report of the New York Pollution Commission, and went over them in a preliminary way, and made some pencil figures on the margins of the leaves of the pamphlet. The line of reasoning that I followed seems to offer promise, and I should like to know what Dr. Soper thinks of it, and whether he has followed it to its conclusions.

The quantity of water that comes into New York Harbor through the Narrows and goes out again, if it is reduced to cubic feet per second, is a tremendous quantity. All together it represents a flow of over three cubic feet per second per thousand of population, for one hundred million people. That is a pretty large population, more than the present population of the whole United States, but there can be no doubt that diluting the sewage from it with this amount of clean, cool, sea water and with the strong tidal currents which exist, would render it reasonably inoffensive.

But of course it is not true that all the water that comes in with every tide is new water. On the other hand, it is equally untrue to assume that the water that comes down the Hudson river and other tributaries of the Bay, and which is represented by the line on Dr. Soper's chart for comparison with the sewage, is the only water available for diluting the sewage. If that were true, if the so-called piston method of computation were correct, if the water that comes back on the flood were the same water that went down on the ebb, then the water of New York Harbor would be fresh ; there would not be a particle of salt-water in it. The fact that there is salt-water in the harbor, and lots of it, is conclusive evidence that sea-water comes in with every tide ; and the fact that the water in New York Harbor is very salt is evidence that the volume of sea-water coming in with each tide is enormous.

I took the figures from the report of Dr. Soper's Commission. There are figures for the estimated volume of fresh waters coming in ; for the volumes of tidal flow up and down ; and for the percentage of sea-water in the water at the different points, as computed from the chlorine of the water at the surface. From these it is easy to get an equation from which can be computed the porportion of the outgoing water that comes back again, and the proportion of new sea-water which enters the harbor at each tide which has never been in the harbor before. And, taking the figures from this same report and making the computation in this way, I found that about 79 per cent. of the water that once goes through the Narrows comes back again. The other 21 per cent. does not come back, but instead, 23* per cent. of the flood tide is made up of new sea-water, water that has never been in the harbor before. And following the same computation at a point on the North river for which figures were given, the percentage was only one or two less, almost the same thing.

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*The whole volume of the flood is smaller than that of the ebb.

Now these analyses relate to the water at the surface. Dr. Soper has told us about the under-run. It seems very clear to me that if that were taken adequately into account, the percentage of sea-water that enters with every flood tide would be much larger than twenty-three per cent. But there are no data to figure that on. I think such data ought to be secured. I think perhaps the way to secure them would be to have a floating laboratory, such as is used in London, and which has been so largely instrumental in establishing the harbor conditions there. But such data do not exist at the present time. It is simply guessing to go beyond the figures in the report, and even those figures must be regarded as inadequate for such a computation. But if twenty-three per cent. of the water that comes in with every flood tide is new, fresh sea-water, then that water would be sufficient to dilute to the extent I have mentioned the sewage from a population of twenty-three millions of people, five times, in round numbers, the population now discharging sewage into the harbor, and Dr. Soper's analyses certainly bear out that proposition, for they indicate a water polluted to only a small fraction of the extent which would be necessary to make it offensive.

Of course it is also true that when New York reaches such a population as twenty-five millions, a great deal of it will be on Staten Island, and on Long Island, and so located that it will not discharge its sewage into the ocean through the upper harbor, and these computations do not take into account the condition of the lower harbor, which are no doubt vastly more favorable for the dispersion of sewage. And so it looks as if it might be centuries rather than decades to the time when radical measures for purifying the sewage of New York city will be required.

There is another side. The degree of dilution of sewage in a body of water to render it satisfactory depends to a very large extent upon the uses to which the body of water is to be put. I have taken the ground strongly in some cases that the character of the body of water receiving sewage had to be taken into account. A standard suitable for one place is not suitable in another. In the case of a stream flowing through country where there are only a few scattered dwellings, the standard must be very different from that where the stream flows through a densely built-up territory and where a nuisance would be objectionable to thousands of people. And in New York harbor millions would be affected.

I suppose there is no body of water in the world of which a bad condition would affect more directly and closely the comfort and happiness and even the health of a larger number of people;

and it may be, when we come to that, that the degree of pollution allowable will be quite different from that which has been established by experience in other cases.

But at any rate, it looks as if any radical change in the method of disposal of New York sewage was a good long way in the future, and as if the habits of the people of future generations, and a lot of other things that we don't know much about, might be elements in the conditions that will finally control. And so I believe that what is wanted at this time is more investigation. I mean adequate and continued investigation of the condition of the water at different depths and at different places, and a study of the currents and of the conditions of sewage dilution. And that is what the situation calls for at the present time, rather than for any radical changes in the places at which sewage is discharged.

NOTE.—The computations upon which the above statements are based are as follows:

Let. E=the volume of the ebb tide passing a given place;

Let. R=the volume of river water in the ebb tide passing;

Let. S=the average proportion of sea water in the ebb tide.

The total quantity of fresh water that goes out at one ebb will then be $E\ (1-S.)$

Of this, R, the volume of river water, goes down not to come back. The rest of the fresh water going down, namely, $E(1-8)-R$, comes back, with the flood tide.

The proportion of the total amount of fresh water which goes down not to come back is then $\frac{R}{E(1-S)}$.

It may be assumed that the proportion of sea-water going down not to come back will be the same as the proportion of fresh water going down not to come back; for, when once mixed, it cannot be supposed that fresh and salt water will ever separate, and the proposition computed for fresh water may therefore he applied to the total volume of water going out with each tide.

Applying this to the Narrows, we have

$E=320{,}000$ cubic feet per second (computed from data on page 35);

$R=23{,}883$ cubic feet per second (page 38);

$S=65$ per cent. (page 67).

Percentage of the volume of each ebb which does not come back at the Narrows, $\frac{R}{E\ (1-S)}=21$ per cent.

And for the Battery.

$E=161{,}000$ cubic feet per second (computed from data on page 35);

$R=$say 18,000 cubic feet per second;

S=45 per cent. (page 67).

Percentage of the volume of each ebb tide which does not come back, $E(1-\frac{R}{S})$ =20 per cent.

Of the gross amount of water flowing out of the Narrows with each ebb:

7 per cent. is river water on its last trip out;
28 per cent. is river water that will come back;
14 per cent. is sea water on its last trip out;
51 per cent. is sea water that will come back.

Allowing for the smaller volume of the flood tide as compared with the ebb, twenty-three per cent. of the whole volume of the flood tide must be new sea water which has never been above the Narrows before, equal to a flow of about 68,000 cubic feet per second throughout the 24 hours.

It is well known that the average per cent. of sea water in the whole stream, taken from top to bottom, is far larger than in the surface water, which alone is represented in the data above indicated. If this difference could be taken into account, it is certain that the computed volume of new sea water entering the harbor with each tide would be much larger—perhaps twice as large as the figure above computed.

There is another element of uncertainty in this computation. The amount of river water entering the harbor must vary enormously from month to month, and even from day to day. The figure given is understood to be a probable average figure. The actual flows when the samples from which the percentage of sea water was computed may have differed considerably from the average, and if so, this would make a difference in the result obtained. Data could be secured which would take this at least approximately into account, and a more accurate computation made, based upon such data.

## APPENDIX NO. XIX.

# DISCHARGE OF SEWAGE INTO BOSTON HARBOR.

The sewage of the Metropolitan District is discharged at three outlets, Deer Island, Moon Island and one mile north of Nut Island. The tidal area back of these outlets has been measured from the maps of the United States Geological Survey, and this area, excluding the Charles river basin, now being cut off by a dam, is as follows:

| | Area, square inches. | Less islands. | Net area, sq. in. | Total area, sq. in. | Total area square miles. |
|---|---|---|---|---|---|
| Boston Sheet......... | 17.62 | 0.41 | 17.21 | | |
| Boston Bay . ...... | 28.07 | 0.37 | 27.70 | | |
| Abington......... ... | 1.53 | | 1.53 | 46.44 | 45.19 |

The tidal area is taken as a line extending from the extreme point of Winthrop to Deer Island, thence to Long Island, thence to Rainsford Island and Quarantine rocks, thence to Peddock's Island and thence to Hull and Nantasket. If the entire tidal area of the outer entrance, namely, from Deer Island to Lovell's Island and the Narrows Light, and straight to the extremity of Nantasket should be taken, an area of 6.07 square miles should be added, making the total tidal area of Boston Harbor, 51.26 square miles.

The total tidal area of New York Harbor above the Narrows, and including the Hudson river, according to the New York Bay Pollution Commission,* is 176 square miles.

**Tidal Volume.** The approximate rise and fall of the tide at Boston Harbor is ten feet. It is not high tide in all parts of the Harbor at the same time; but as I have no data upon this, and as the Harbor is comparatively small and compact the differences are not taken into account.

Multiplying the area back of Long Island by 10 feet, I find that the total tidal volume, passing the outlets of the sewers, is 12,600 million cubic feet.

The corresponding volume of tide at the Narrows, according to The New York Bay Pollution Commission's report, is 13,200 million cubic feet.

*Pages 36 and 37.

The entire area drained by the Metropolitan Sewerage District, including Boston, is about 187 square miles, and the estimated population, based on the census of 1900, is 1,042,400.

The tidal flow as computed above amounts to 291,000 cubic feet per second as a continuous flow, or 279 cubic feet per second per thousand population, by the census of 1900.

Corresponding figures for New York Harbor are as follows :

| | |
|---|---|
| Population, 1900 | 4,275,000 |
| Cubic feet per second at Narrows | 306,000 |
| Cubic feet per second per 1,000 of population | 72 |

In 1900 the Massachusetts State Board of Health made an exhaustive report on the discharge of sewage into Boston Harbor. This report makes statements regarding the appearance of sewage on the surface of the water, and shows a map indicating the areas in which the appearance of sewage can be detected, and the areas in which it is assumed that it will be detected in future with the discharges further developed.

The report seems to assume that the dilution of the Harbor is ample for all the sewage contemplated ; and the only questions raised were as to the best means of discharging the sewage to prevent local nuisances.

## APPENDIX NO. XX.

# DETAILED SCHEDULE OF ESTIMATE OF COST OF PASSAIC VALLEY TRUNK SEWER.

In estimating the cost of the trunk sewer, I have used the blue print copies of the plans showing the location and profile of the proposed main sewer, which were obtained from the Passaic Valley Sewerage Commission.

Excavation is taken at $1 per cubic yard where the trench is presumably dry, otherwise at $1.50 ; and in the absence of other information it is assumed that the trench will be wet where the bottom of the sewer is below the river level. Where rock is encountered excavation for that part is taken at $4 per cubic yard. The masonry is taken as concrete masonry at $8 per cubic yard.

To these figures are added the cost of replacing the surfaces of roads, cost of paving, railroad crossings, stream crossings, maintaining street car lines, buildings, right of way, etc.

A detailed schedule is as follows :

## TRUNK SEWER.

### COST OF EXCAVATION AND MASONRY.

| Diam. in feet. | Av'g. depth, feet. | Total length of section, feet. | Cost per lineal foot. | | | Total. | Total cost in district. |
|---|---|---|---|---|---|---|---|
| | | | Excava'n. | Masonry. | Total. | | |
| FROM PROSPECT STREET TO MARKET STREET, PATERSON (5.6 MILES). | | | | | | | |
| 4.0 | 14.2 | 2,120 | $ 6.48 | $ 3.36 | $ 9.84 | $ 20,800 | |
| 4.5 | 12.3 | 1,150 | 5.96 | 4.24 | 10.20 | 11,700 | |
| 5.5 | 17.03 | 1,360 | 10.14 | 6.32 | 16.46 | 22,400 | |
| 6.0 | 15.5 | 15,210 | 10.61 | 7.52 | 18.13 | 276,000 | |
| 6.5 | 21.5 | 9,730 | 15.15 | 8.88 | 24.03 | 234,000 | $ 564,900 |
| FROM MARKET STREET, PATERSON, TO PUMPING STATION (15.6 MILES). | | | | | | | |
| 7.0 | 25.4 | 4,500 | 21.26 | 10.32 | 31.58 | 142,000 | |
| 7.5 | 27.4 | 11,070 | 26.34 | 11.76 | 38.10 | 421,000 | |
| 8.0 | 18.4 | 2,310 | 14.70 | 13.36 | 28.06 | 65,000 | |
| 9.0 | 12.4 | 3,840 | 10.34 | 16.96 | 27.30 | 105,000 | |
| 9.5 | 12.25 | 11,330 | 10.72 | 18.88 | 29.60 | 335,000 | |
| 10.0 | 14.4 | 13,830 | 13.35 | 20.96 | 34.31 | 473,000 | |
| 10.5 | 17.25 | 3,060 | 77.00 | 23.12 | 40.12 | 123,000 | |
| 11.5 | 22.0 | 11,970 | 24.15 | 27.76 | 51.91 | 620,000 | |
| 12.0 | 39.0 | 8,620 | 48.90 | 30.24 | 79.14 | 682,000 | |
| 12.5 | 34.0 | 4,480 | 42.60 | 32.72 | 75.32 | 337,000 | |
| 13.0 | 25.9 | 7,440 | 32.10 | 35.36 | 67.46 | 502,000 | 3,805,000 |
| JERSEY CITY AND BAYONNE SECTION (1.1 MILES). | | | | | | | |
| 13.5 | 11.6 | 5,690 | 23.20 | 38.16 | 61.36 | 349,000 | 349,000 |

Total cost of excavation and masonry............. $4,718,900

## ESTIMATED COST OF WORK IN CONNECTION WITH THE CONSTRUCTION OF THE INTERCEPTING SEWER FROM PROSPECT STREET TO MARKET STREET, PATERSON.

### PAVING.

| Street | Diam. of Sewer feet. | Average width of paving to be removed, feet. | Length, feet. | Kind of paving. | Number of square yards. | Price per sq. yd. | Total. |
|---|---|---|---|---|---|---|---|
| River | 4 | 13.0 | 1,600 | Asphalt, | 2,300 | $2.50 | $5,750 |
| " | 4 feet 6 inches and 5 feet 6 inches | 15.5 | 2,450 | Brick, | 4,230 | 1.50 | 6,350 |
| Boulevard | 6 | 16.5 | 500 | Macadam, | 925 | 1.00 | 925 |
| " | 6 | 16.5 | 2,000 | Macadam, | 3,700 | 1.00 | 3,700 |
| " | 6 | 16.5 | 500 | Macadam, | 925 | 1.00 | 925 |
| " | 6 | 18.5 | 1,000 | Macadam, | 2,050 | 1.00 | 2,050 |
|  | 6 feet 6 inches | 18.0 | 500 | Macadam, | 1,000 | 1.00 | 1,000 |
|  | 6 feet 6 inches | 20.0 | 1,500 | Macadam, | 3,300 | 1.00 | 3,300 |
| Total cost of paving |  |  |  |  |  |  | $24,000 |

### OTHER STRUCTURES.

|  |  |  |
|---|---|---|
| Maintaining Street-car Lines. |  |  |
| 2,450 feet, over an average width of trench of 12.5 feet, @ $10 per foot | $24,500 |  |
| Crossings. |  |  |
| 2 double-track trolley lines | 1,000 |  |
| 1 railroad crossing, double track, cut 30 feet deep | 2,000 |  |
| Bridges. |  |  |
| Erie railroad bridge | 10,000 |  |
| New York, Susquehanna & Western bridge | 5,000 |  |
| Highway bridge, Thirty-third street | 5,000 |  |
| Supporting buildings. |  |  |
| 1,200 feet, more or less | 16,000 |  |
| Electric conduits, etc., | 7,500 |  |
|  |  | $71,000 |
| Land damages, etc., |  | 25,000 |
| Total estimated cost of paving and other structures |  | $120,000 |

## ESTIMATED COST OF WORK IN CONNECTION WITH THE CONSTRUCTION OF THE MAIN TRUNK SEWER BETWEEN MARKET STREET, PATERSON, AND THE PUMPING STATION AT NEWARK.

### PAVING.

| Street. | Profile sheet number. | Diam. sewer in feet. | Aver'g width paving to be removed, feet. | Length in feet. | Kind of paving | Number of square yards. | Price per yard | Total |
|---|---|---|---|---|---|---|---|---|
| Paterson & Aquackanonck. | | | | | | | | |
| Dundee drive | 49-52 | 7.0<br>7.5 | 20.5 | 6,800 | Macadam, | 15,500 | $1.00 | $15,500 |
| Passaic. | | | | | | | | |
| Passaic | 44 | 8.0 | 19.0 | 100 | Asphalt, | 210 | 2.50 | 525 |
| State | 43-44 | 8.0 | 20.0 | 1,300 | Macadam, | 2,900 | 1.00 | 2,900 |
| Passaic to Newark. | | | | | | | | |
| R'v'r R'd | 26-42 | 9.5 | 20.0 | 7,000 | Macadam, | 15,600 | 1.00 | 15,600 |
| " | 26-42 | 10.0 | 22.0 | 12,000 | Macadam, | 29,400 | 1.00 | 29,400 |
| " | 26-42 | 10.5 | 23. | 3,100 | Macadam, | 7,900 | 1.00 | 7,900 |
| " | 26-42 | 11.5 | 25.0 | 1,900 | Macadam, | 5,300 | 1.00 | 5,300 |
| Newark. | | | | | | | | |
| Riverside avenue | 24-25 | 11.5 | 25.0 | 1,000 | Macadam, | 2,800 | 1.00 | 2,800 |
| Passaic | 21-22 | 11.5 | 28.0 | 3,300 | Stone, | 10,000 | 1.50 | 15,000 |
| CarlislePl | 21 | 11.5 | 26.0 | 300 | Stone, | 870 | 1.50 | 1,300 |
| Ogden | 20-21 | 12.0 | 29.0 | 2,500 | Macadam, | 8,000 | 1.00 | 8,000 |
| Front | 18-19 | 12.0 | 31.0 | 3,500 | Stone, | 12,000 | 1.50 | 18,000 |
| S. Canal | 17-18 | 12.0 | 30.0 | 900 | Stone, | 3,000 | 1.50 | 4,500 |
| Market | 16-17 | 12.0 | 30.0 | 2,700 | Stone, | 9,000 | 1.50 | 13,500 |
| Chambers | 16 | 12.5 | 30.0 | 1,000 | Stone, | 3,330 | 1.50 | 5,000 |
| Niagara | 15 | 13.0 | 29.5 | 300 | 100 Asphalt | 320 | 2.50 | 800 |
| | | | | | 200 Stone, | 650 | 1.50 | 975 |

Total cost of repaving . . . . . . . . . . . . . . . . . . . . . . . . . $147,000

### MAINTAINING STREET CAR LINES.

| Street. | Number of tracks. | Diam. of sewer feet. | Width, top of trench. | Length in feet. | Price per foot. | Total. |
|---|---|---|---|---|---|---|
| Passaic. | | | | | | |
| Passaic.... | 1 | 8.0 | 16 | 100 | $15 | $1,500 |
| River Drive | 1 | 9.5 | 17 | 1,100 | 15 | 16,500 |
| Newark. | | | | | | |
| Carlisle Pl. | 1 | 11.5 | 23 | 300 | 20 | 6,000 |
| Ogden.... | 2 | 12 | 25-30 | 1,600 | 40 | 64,000 |
| | 1 | 12 | 25-30 | 900 | 25 | 22,500 |
| Front..... | 1 | 12 | 25-30 | 1,500 | 25 | 37,500 |
| | 2 | 12 | 25-30 | 500 | 40 | 20,000 |
| Market.... | 2 | 12 | 25-30 | 2,700 | 40 | 108,000 |

Cost of maintaining street car lines .................... $276,000

### STREET CAR CROSSINGS

| | | | |
|---|---|---|---|
| Passaic. | | | |
| Passaic ... | 1 | | $500 |
| Newark. | | | |
| Bridge.... | 2 | 12 | 500 |
| Ferry..... | 2 | 12.6 | 500 |
| Avenue L..... | 2 | 13 | 500 |

Cost of maintaining street-car crossings, $2,000

### MAINTAINING RAILROAD CROSSINGS.

| NEWARK. | Hering's survey, profile sheet number. | Number of tracks. | Size of sewer. | Depth of cut feet. | Cost. | Remarks. |
|---|---|---|---|---|---|---|
| Grade crossings : | | | | | | |
| Newark & Paterson.... | 33 | 2 | 11.5 | 23 | $ 3,000 | |
| " ... | 22 | 5 | 11.5 | 28 | 5,000 | |
| C. R. R. of N. J........ | 13 | 14 | 13.0 | 30 | 30,000 | Swamp on both sides. |
| Bridges : | | | | | | |
| Pennsylvania Railroad.. | 18 | | 12.0 | 36 | 30,000 | Stone arch, main line 20 feet span. |
| " | 16 | 2 | 12.5 | 36 | 5,000 | Girder. |
| " | 14 | 2 | 13.0 | 32 | 5,000 | Girder. |
| N.Y. &Greenwood Lake. | 26 | | 11.5 | 25 | 5,000 | Girders. |
| D., L. & W. R. R....... | 20 | 4 | 12. | 32 | 15,000 | |

Cost of maintaining railroads.............. $98,000

### SUPPORTING BUILDINGS.

| | Hering's survey, profile sheet number. | Size of sewer. | Depth of cut feet. | Cost. | Remarks. |
|---|---|---|---|---|---|
| Passaic: | | | | | |
| Engine House, etc. | 44 | 8.0 | 15 | $2,000 | |
| Newark: | | | | | |
| Gas tanks, etc.. | 25 | 11.5 | 15 | 2,000 | |
| Ogden street.... | 20-21 | 12.0 | From 25 to 40 feet | 250,000 | 10,000 feet, more or less supported, at $25 per foot. |
| Front street... | 18-19 | 12.0 | | | |
| Canal street.... | 17-18 | 12.0 | | | |
| Market street... | 16-17 | 12.0 | | | |
| Total cost of supporting buildings.... | | | | | $254,000 |

### MISCELLANEOUS OBSTACLES.

| | |
|---|---|
| Passaic. | |
| Old buildings | $ 2,000 |
| Newark. | |
| Three small buildings | 3,000 |
| To avoid Paint Manufactory, involving cut and two railroad crossings | 15,000 |
| Culverts, pipe, etc., | 14,000 |
| | $34,000 |

### STREAM CROSSING.

| | |
|---|---|
| Weasel Brook, Acquackanonck | $ 1,000 |
| Third river siphon, Nutley | 20,000 |
| Second river siphon, Belleville | 2,000 |
| Other small crossings | 4,000 |
| | $27,000 |

### SWAMPY LAND.

| | | | |
|---|---|---|---|
| Newark Meadows.......... | 6,600 | $15 | $99,000 |
| | 1,200 | 10 | 12,000 |
| | 200 | 5 | 1,000 |
| | 600 | 15 | 9,000 |
| In or near river | 4,000 | 15 | 60,000 |
| Total | | | $181,000 |
| Side hill excavation, 11,000 feet, @ $3, | | | 33,000 |

## ESTIMATED COST OF WORK IN CONNECTION WITH THE CONSTRUCTION OF THE MAIN SEWER ACROSS BAYONNE.

### RAILROAD CROSSINGS.

| | Sheet number. | Number of tracks. | Size of sewer, feet. | Depth of cut. | Cost | Remarks |
|---|---|---|---|---|---|---|
| GRADE CROSSING. | | | | | | |
| L. V. & P. R. R. | 5 | 7 | 13.5 | 33 | $20,000 | |
| BRIDGES. | | | | | | |
| L. V. R. R. | 4 | 2 | 13.5 | 20 | 10,000 | Through pier |
| C. R. R. of N. J. | 4 | 4 | 13.5 | 20 | 15,000 | do |
| Total | | | | | $45,000 | |

### SWAMPY LAND.

| | |
|---|---|
| Bayonne, 1400 feet @ $10 per foot | $14,000 |

### SUMMARY OF ESTIMATED COST OF TRUNK SEWER.

| | Paterson to Market Street. | Market St. to pumping station. | Bayonne. | Total. |
|---|---|---|---|---|
| Paving | $24,000 | $147,000 | | $171,000 |
| Street car lines | 24,500 | 276,000 | | 300,500 |
| Railroad and St. car crossings | 23,000 | 100,000 | $45,000 | 168,000 |
| Supporting buildings | 16,000 | 254,000 | | 270,000 |
| Stream crossings | | 27,000 | | 27,000 |
| Swampy land | | 181,000 | 14,000 | 195,000 |
| Side Hill excav'n. | | 33,000 | | 33,000 |
| Miscellaneous | 7,500 | 34,000 | | 41,500 |
| Land | 25,000 | 150,000 | 25,000 | 200,000 |
| Total, auxiliary work, right of way, etc., | $120,000 | $1,202,000 | $84,000 | $1,406,000 |

| | Paterson to Market Street. | Market St. to pumping station. | Bayonne. | Total |
|---|---|---|---|---|
| Sewers. | | | | |
| Branch sewer north of river in Paterson, 24 inch to 36 inch, complete | $ 40,000 | | | $ 40,000 |
| Main Sewer.. | 564,900 | $3,805,000 | $349,000 | 4,718,900 |
| Lateral sewers, Wallingford branch, Lyndhurst branch, Harrison & Kearney branch; sizes, 12 inch to 42 inches long, 11 miles..... | | 407,000 | | 407,000 |
| | $724,900 | $5,414,000 | $433,000 | $6,571,900 |

### FORCE MAINS, PUMPING STATIONS AND GREASE REMOVAL TANK.

| | | |
|---|---|---|
| Force Mains. | | |
| 4 lines, 6 feet cast iron pipe across Newark Bay, 8680 feet, each line @ $50 per foot.... ............. | | $1,736,000 |
| 2 lines, 8 feet cast iron pipe under New York Bay, 13,330 feet each, @ $88 per foot.......... .......... | | 2,344,000 |
| Pumping Stations. | | |
| Main pumping station, complete...... | | 1,100,000 |
| 2 small auxiliary pumping stations, for laterals ...................... | | 60,000 |
| Grease Removal Tank. | | |
| One hour's capacity; maximum capacity of sewer, 13 million gallons ...... | $200,000 | |
| Screening appliances.............. | 100,000 | 300,000 |
| | | $12,111,900 |
| Engineering and contingencies, 10 per cent......................... | | 1,211,190 |
| Total cost of trunk sewer ........... | | $13,323,090 |

## ESTIMATED COST OF OPERATION OF TRUNK SEWER.

(COST PER CAPITA.)

| | Year 1910 | Year. 1932 |
|---|---|---|
| Population of District | 665,000 | 1,290,000 |
| Length of main sewer, miles | 26.7 | |
| Length of lateral sewers, miles | 12.2 | |
| Total length of sewers | 38.9 | 45 |
| Average quantity of sewage pumped daily, million gallons | 83 | 160 |
| Average pumping lift, feet | 35 | 35 |
| Cost of pumping | $70,000 | $121,000 |
| Cost of operating secondary stations | 13,000 | 24,000 |
| Administration and care of sewers | 45,000 | 80,000 |
| Total cost | $128,000 | $225,000 |
| Cost per capita | 19c. | 17c. |
| Cost taken for this estimate | 18 cents | |
| Cost of operating grease removal and close screening @ $1 per million gallons, = 4.6 per capita annually | 5 " | |
| Total cost of operation per capita annually | 23 cents | |

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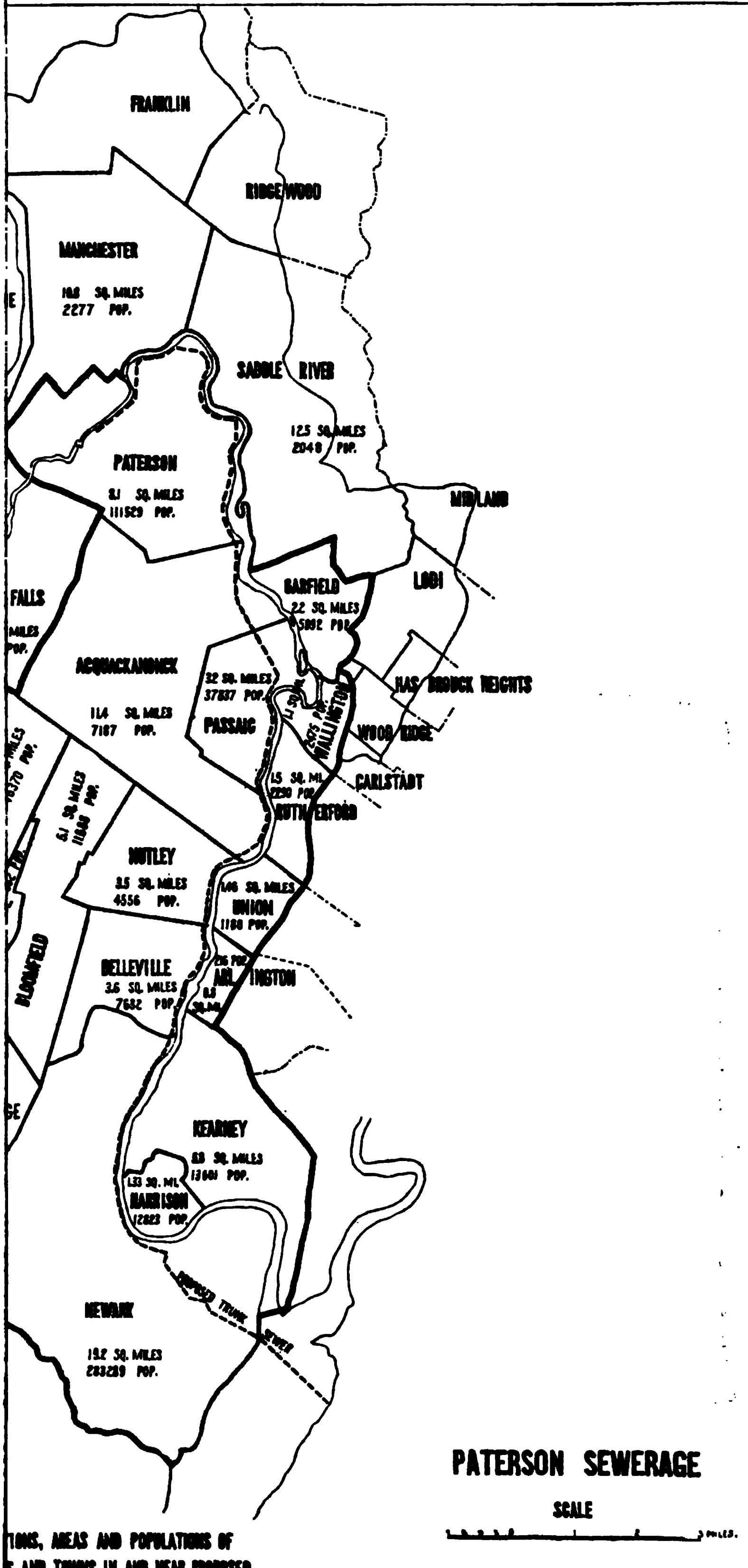
" 7 Profiles of Outlets of Sewers.

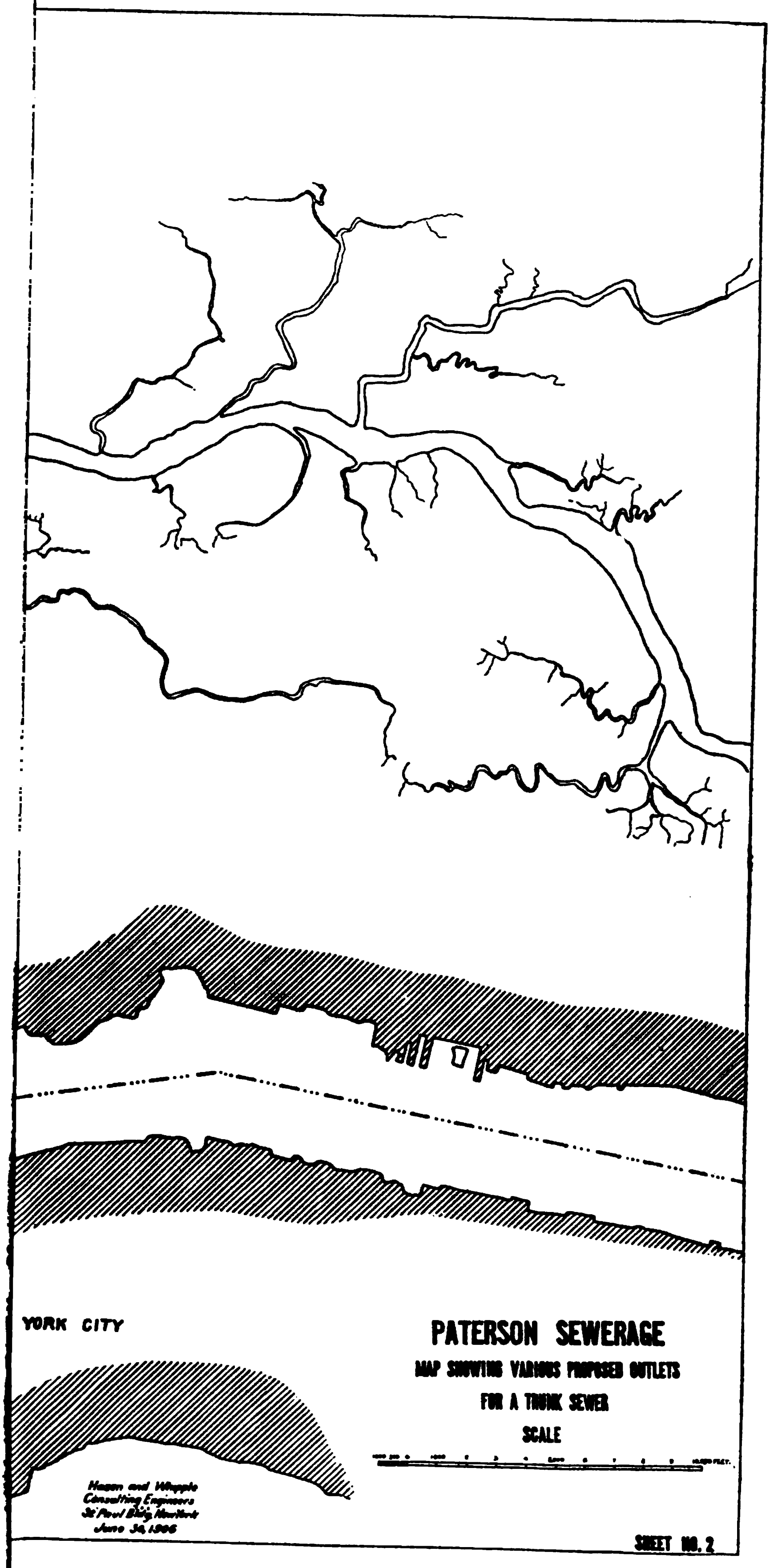


## PATERSON SEWERAGE

TIONS, AREAS AND POPULATIONS OF
S AND TOWNS IN AND NEAR PROPOSED
ICT

*Hazen and Whipple*
*Consulting Engineers*
*St Paul Bldg, New York*
*June 30, 1906*

SHEET NO. 1



# PATERSON SEWERAGE

MAP SHOWING VARIOUS PROPOSED OUTLETS
FOR A TRUNK SEWER
SCALE

Hazen and Whipple
Consulting Engineers
St Paul Bldg New York
June 30, 1906

SHEET NO. 2

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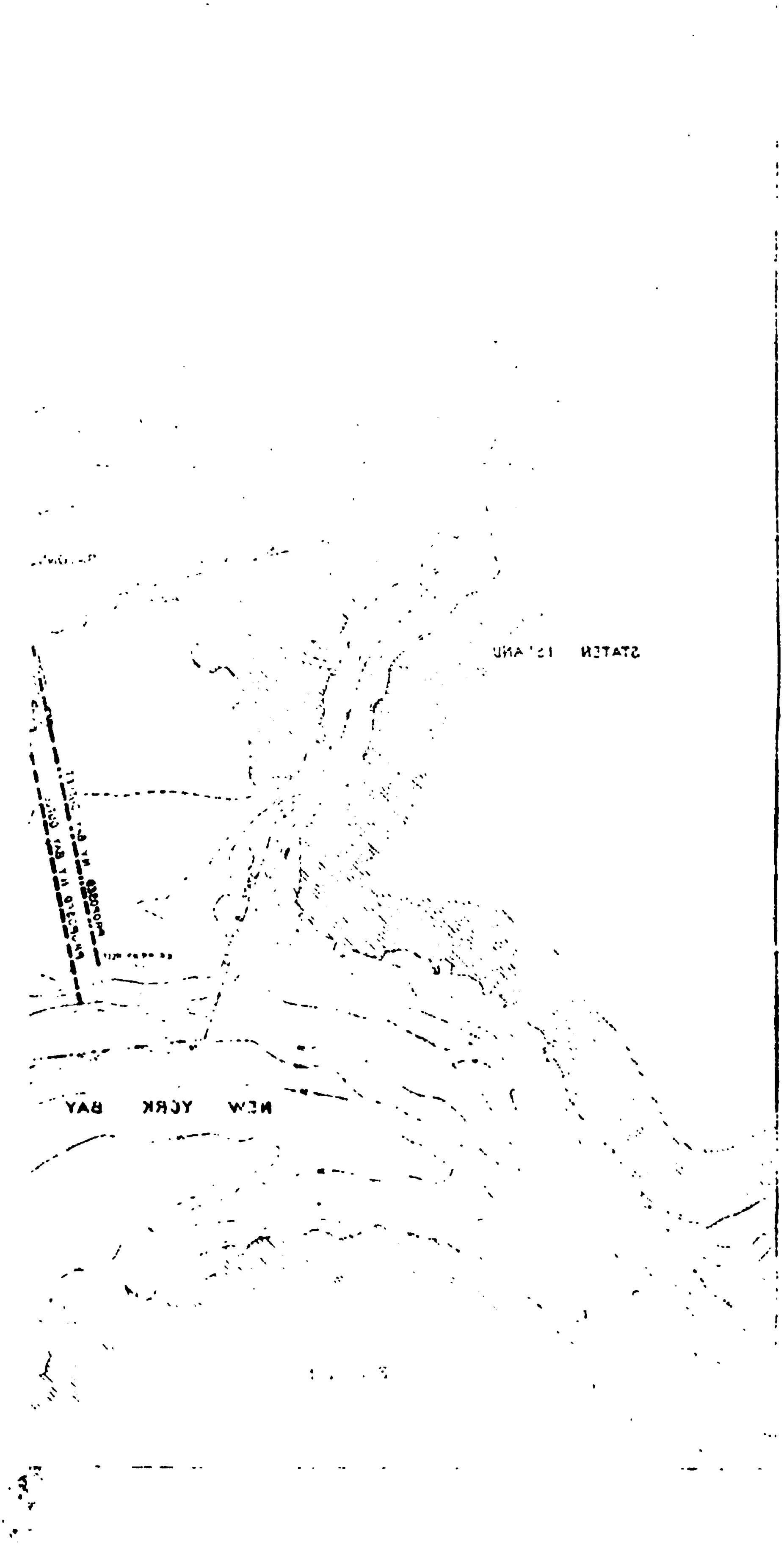
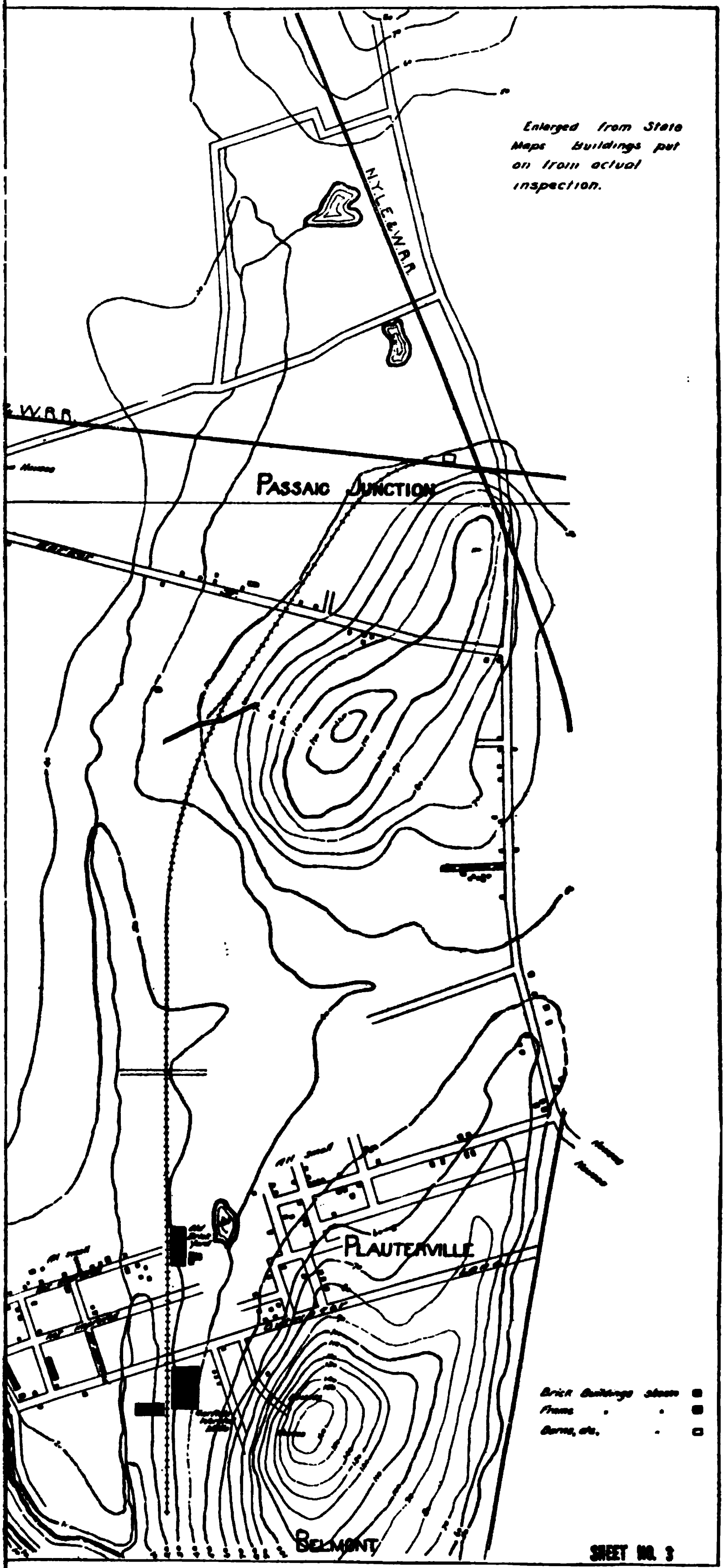
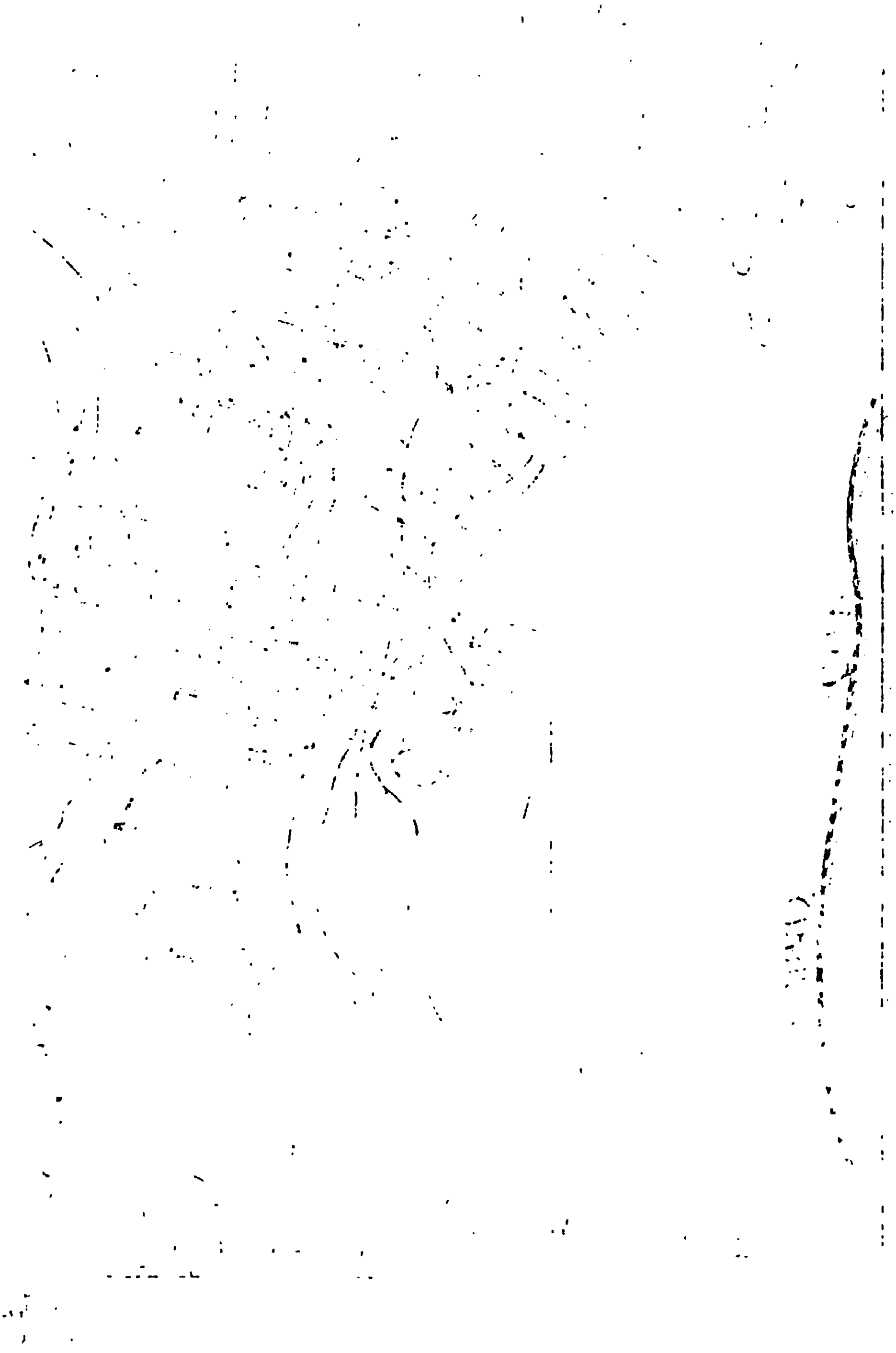
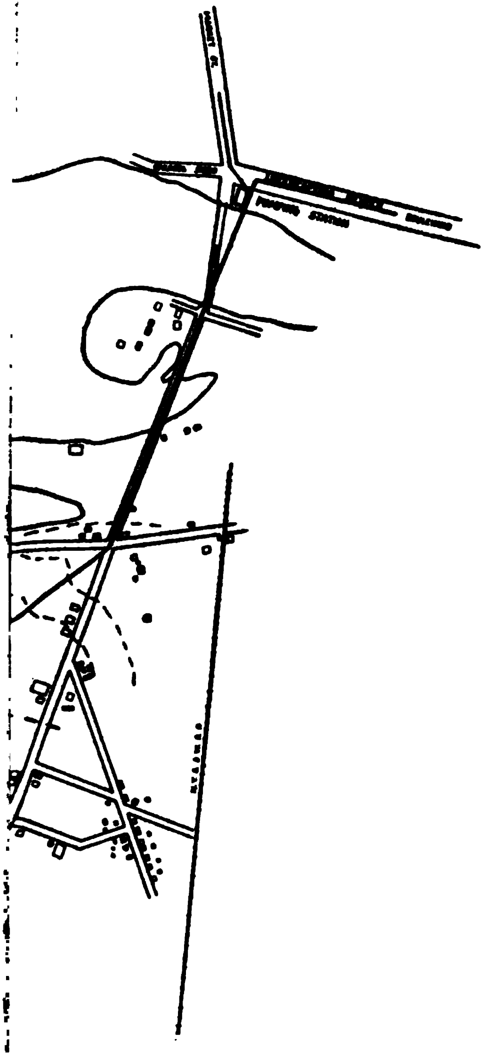

STATEN ISLAND
NEW YORK BAY

Enlarged from State Maps Buildings put on from actual inspection.
N.Y.L.E.&W.R.R.
E.W.R.R.
PASSAIC JUNCTION
PLAUTERVILLE
BELMONT
Brick Buildings shown ■
Frame " " ■
Barns, etc. " □
SHEET NO. 3





# PATERSON SEWERAGE

MAP SHOWING DETAILED LOCATION AND GENERAL
ARRANGEMENT OF SEWAGE PURIFICATION WORKS
AND HOUSES NOW EXISTING IN THE NEIGHBORHOOD

SCALE

Hazen and Whipple
Consulting Engineers
St Paul Bldg. New York
June 30, 1906

SHEET NO. 4

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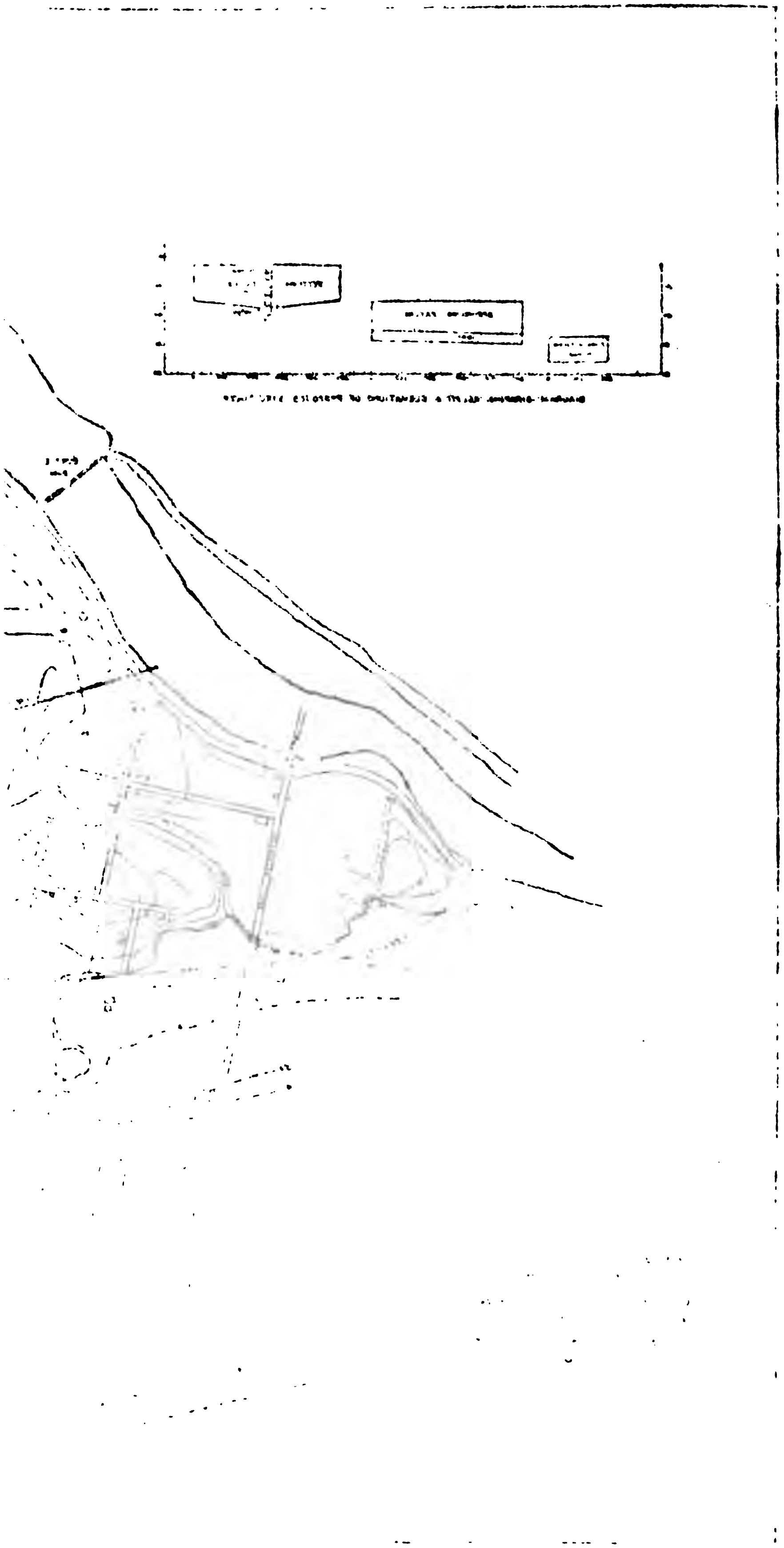


# PATERSON SEWERAGE

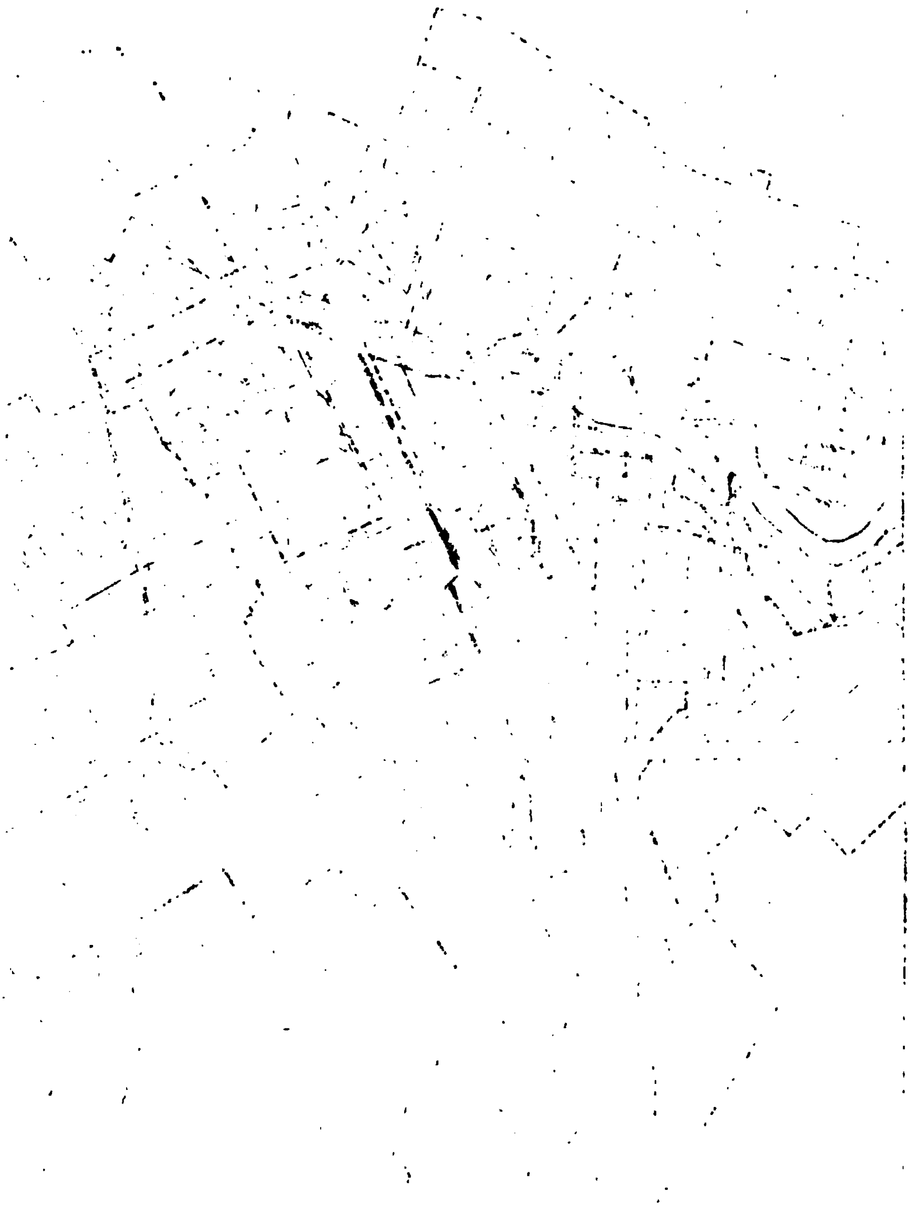
MAP SHOWING CITY, INTERCEPTING SEWER
AND PROPOSED PURIFICATION WORKS

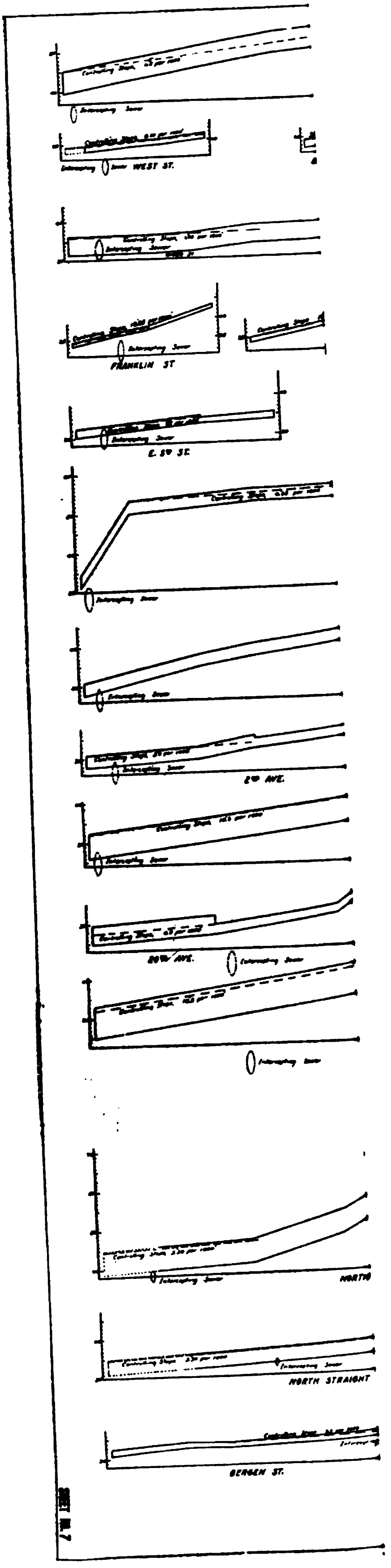
SCALE

2000 1500 1000 500 0 2000 4000 6000 FEET

SHEET NO. 5

Sewers




Controlling Slope
Intercepting Sewer
Controlling Slope
Intercepting Sewer WEST ST.
Controlling Slope
Intercepting Sewer
Controlling Slope
Intercepting Sewer
FRANKLIN ST
Controlling Slope
Controlling Slope
Intercepting Sewer
E. 5th ST.
Controlling Slope
Intercepting Sewer
Intercepting Sewer
Controlling Slope
Intercepting Sewer
2nd AVE.
Controlling Slope
Intercepting Sewer
Controlling Slope
20th AVE.
Intercepting Sewer
Controlling Slope
Intercepting Sewer
Controlling Slope
Intercepting Sewer
NORTH
Controlling Slope
Intercepting Sewer
NORTH STRAIGHT
Controlling Slope
BERGEN ST.

SHEET NO. 7